SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1923.

GENERAL PHYSICS.

1005. *Physical Constants and Ultimate Rational Units.* **G. N. Lewis.** (Phil. Mag. 45. pp. 266–275, Feb., 1923.)—The paper is a discussion of units based on the view that every physical constant indicates some flaw in our scientific system, and that it becomes as useful a scientific service to eliminate constants as to discover them. Such elimination has often been secured by a mere change in the units of measurement. Examples are given in the c.g.s. system, *e.g.* heat and work expressed in terms of the same unit, the constant of Dulong and Petit, the electrostatic and electromagnetic systems, etc. In the latter case the most rational choice of temporal and spatial units is one whereby the velocity of light becomes unity, so that the same unit can be used for time and length, a use which does not mean that the two concepts are indistinguishable. Acting on these lines, E. Q. Adams and the author advanced their theory of ultimate rational units, according to which there is possible a set of units in terms of which all universal constants will be reduced to simple numbers. To determine the new units of length and mass, two relations must be sought which are as simple and as inevitable as those used (in the paper) to eliminate the arbitrary units of temperature and time. These 2 relations will then enable the replacement of the gramme and cm. by ultimate rational units. Only one of these relations, however, has yet been discovered, and this permits the expression of all other units in terms of a single one for which the centimetre has been retained. The new unit of mass or energy was obtained by considering the electronic charge. In ordinary units the square of a charge has the dimensions of energy times length, and if the new units of mass and energy are taken such that $(4\pi e)^2$ is unity and dimensionless, then the new unit of energy or mass becomes the reciprocal centimetre, and 1 erg $= 2\cdot779 \times 10^{16}$ reciprocal cm., while 1 gram. $= 2\cdot499 \times 10^{37}$ recip. cm. Thus energy and mass acquire the dimensions of curvature, or frequency, or acceleration, in fact all physical quantities are now capable of reduction to the dimensions of a power of length. Although this change seems radical, the author claims to be introducing no new element into the theory of physical dimensions. The first success of the theory came in the calculation of the constant of Stefan's law, *viz.* if E/*v* is the energy-density of a hohlraum, $E/\nu = aT^4$. When these quantities were all expressed in terms of ultimate rational units, the const. a became 1, and a calculated value of Stefan's constant rendered available of much higher accuracy than hitherto obtained, *viz.* 5·70, which is almost in perfect accord with the Coblentz experimental (1917) value 5·72 ± 0·012. With an accurate value of Stefan's constant, it was possible to obtain therefrom the constant of Planck, assuming the correctness of his radiation formula, *viz.* $6{\cdot}560 \times 10^{-27}$. Recent work by Coblentz afforded $6{\cdot}557 \times 10^{-27}$. In classical thermodynamics, the theory of an ideal monatomic gas is given by $S = 3/2R \log T + R \log \nu + \text{const.}$, and the constant has been regarded as undetermined and indeterminable. With the advent of the third law of thermodynamics, and especially in consequence of Planck's work, a definite finite entropy can now be assigned to every substance, and this can be calculated from simple measurements. By a simple deduction from the theory of ultimate rational units, and, with no other information whatever, it is also shown how to calculate the entropy of any monatomic gas. Agreement of the calculated with the experimental values for He, A, Cd, and Hg, is remarkable, being in each case within the limits of possible experimental error. The constants employed are claimed to furnish calculated values with an accuracy at least 10 times that of any present measured value. The author claims his results in support of the probable general law proposed by Tolman that every new fundamental constant will be found to be dimensionless in ultimate rational units. One fundamental constant, however, which is not dimensionless in ultimate rational units is Rydberg's, and the author opines that by it the last element of arbitrariness may be removed from the system of units and the cm. removed by choosing the mass of the electron as the unit of mass, or $h + \nu_0$ (Rydberg's constant) as the unit of energy. He, however, prefers to wait awhile for experience to decide which choice of rational units is likely to prove the best permanently.

An appendix by **O. J. L.** argues that attempts to unify essentially different physical quantities and obliterate the constants connecting them can only result in confusion. H. H. Ho.

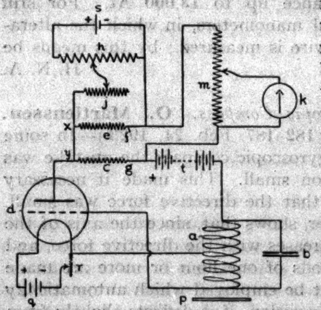
1006. *Some Experiments on the Impact of Hydraulic Jets.* **A. H. Gibson** and **F. Heywood.** (Phil. Mag. 45. pp. 229–238, Jan., 1923.)—No previous experiments would appear to have been made to determine the maximum size of the orifice of a Pitot tube which can be used to give correctly the "velocity head" of a free jet. Consideration of the impact of a jet on a hemispherical cup, assuming the jet to be deflected 180°, gives an average pressure $2av^2/Ag$ (where a and A are the areas of the jet and the projected area of the hemisphere) which is $> v^2/2g$ as long as $A > 4a$. This indicates that so long as $A < 4a$, the cup is too small to permit the assumed deviation. Experimental determinations of the total force of impact on a hemispherical cup showed a linear increase of the force as the area of the cup was increased to between 3·6 and 4 times the area of the jet, after which it remained practically constant. Another set of experiments was undertaken to determine the pressure in a vertical tube, connected to a water gauge, due to the impact of a jet issuing from an orifice in the base of a vessel, as the relative areas of jet and tube was varied. This pressure was sensibly equal to $v^2/2g$ as long as the area of the tube did not exceed 3·4 to 4 times that of the

jet, but fell off rapidly with further increase of tube area. By colouring the water in the tube, it was found that a well-defined boundary between the water of the jet and that in the tube could be observed, with a stream-line jet, but that with a turbulent jet the colour was instantly dissipated.
W. G. B.

1007. *The Pressure Balance. The Normal Instrument for High Pressures.* **L. Holborn.** (Zeits. Vereines deutsch. Ing. 67. pp. 188–189, Feb. 24, 1923. From the Reichsanstalt.)—The pressure balances at the Reichsanstalt are described. It is found best not to use any packing between the vertical piston, to the top of which weights are hung to measure the pressure, and the cylinder into which it fits. The pressure to be measured is transmitted to the interior of this cylinder by means of castor oil, and the fit of the piston can, for moderate pressures, be made so good that the oil only flows out slowly and can be pumped back as required. The sectional area of the piston is determined by comparison with a mercury manometer, which reads to 16 At. By using a second pressure balance and a differential manometer the first instrument can be calibrated up to 32 At., and so step by step upwards. Up to 100 At. the cross-section of the piston does not vary more than 0·01 per cent. The piston is constantly rotated to and fro through some 40° about its vertical axis, which ensures smooth working, and is always adjusted to exactly the same position in the cylinder when a reading is taken. There are two balances with pistons of 1 $\mathrm{cm.}^2$ section, carrying 250 kg., and another with 0·2 $\mathrm{cm.}^2$ section, carrying 200 kg., and so reading up to 1000 At. The correction here for elastic deformation is about 0·05 per cent. Bridgman has used a pressure balance up to 13,000 At. For still higher pressures he has used electrical manometers, in which the alteration in the resistance of a manganin wire is measured; by this means he has measured up to 20,000 At.
H. N. A.

1008. *Development of the Gyroscopic Compass.* **O. Martienssen.** (Zeits. Vereines deutsch. Ing. 67. pp. 182–187, Feb. 24, 1923.)—In some of the early attempts to construct a gyroscopic compass the mistake was made of making the time of vibration small. This made it necessary to use a small rotor, with the result that the directive force was small. The theory, as developed in this paper, shows that, since the axis of the rotor is free, the time of vibration increases with the directive force, and in modern instruments vibration periods of one hour or more are made use of; this implies that devices must be employed which automatically bring back the rotor axis to the zero position, if it deflects slightly from it. Anschütz and Co. employ for this damping effect an arrangement by which air is drawn into the gyroscope case through a hole near the axis, and blown out through a small opening in such a way that, when the gyroscope deflects a very little to either side of the N.-S. direction, the air stream is displaced out of the middle line, and the reaction produces a turning moment about the vertical axis, which brings the gyroscope back to the proper position. This firm, since 1910, has constructed a three-gyroscope compass; one of the rotors has its axis in the N.-S. direction, while those of the other two are in the same horizontal plane, the axes making angles of 30° on either side of that of the main rotor; the three are joined by a system of links in such a way that the virtual moment of inertia about the N.-S. line is increased. The whole arrangement is attached to a spherical float, which swims in a vessel containing mercury in the interior of the instrument. There is an attachment by means of which this master compass actuates a number of dials in different parts of the ship. These instruments were used by the German Navy during the war, and proved satisfactory, except on submarines, where the vibration was too much for them. Other modern forms are described, including one designed to measure the inclination of the bore-hole in deep borings, particularly in connection with the method of sinking shafts in soft ground, by putting down a series of holes fairly close together along the circumference of a circle somewhat larger than the shaft to be sunk, and pumping cold brine through them, so as to form a " frost wall " within which the shaft can be excavated. H. N. A.

1009. *Electrical Apparatus for Measuring Small Motions.* **H. A. Thomas.** (Engineer, 135. pp. 138–140, Feb. 9, 1923.)—This apparatus consists, as shown in the diagram, of a high-frequency electrical oscillator, the inductance coil *a* of which is arranged in close proximity to the metallic body *p* whose motion is to be measured. The inductance coil *a* is mounted on a spring support and is capable of being moved by means of a micrometer screw. In the oscillation circuit is arranged a high resistance *c* of about 2,000 ohms, and the normal difference of potential is balanced by an auxiliary circuit consisting of a battery *s* and the resistances *e* and *j*. The two points *f* and *g* are adjusted to be normally at about the same potential, and any subsequent change is detected by means of a high resistance galvanometer *k* connected across these two points. As the inductance of the coil *a* varies during the motion of the body *p*, the current in the galvanometer varies in proportion, so that by moving the coil *a* by means of the micrometer screw, the body *p* being stationary, the galvanometer can be calibrated. In the case of a definite and constant movement, an ordinary d'Arsonval galvanometer is sufficient, but in the case of pulsating motions and vibrations, an Einthoven string galvanometer may be used. The coil *a* may consist of about 100 turns of No. 30 S.W.G. insulated copper wire wound on a 1½-in. ebonite bobbin attached to a steel leaf spring fixed to a casting sliding on a vertical column. In cases where the vibrating body is non-metallic, a thin sheet of tinfoil gummed to the surface under observation is all that is required. Motions from one-millionth to one-eighth of an inch can be measured by providing the galvanometer with a variable shunt. The original paper gives a photograph of the moving coil and control panel and some diagrams obtained in its use. The instrument is applicable to the analysing of the transient conditions existing in all types of engineering structures when subjected to live loads, *e.g.* bridges, cantilevers, engine cylinders, airship and aeroplane structures during flight, shear stresses in propellers in air and water, also pulsating liquid or gaseous pressures, an apparatus for measuring which is illustrated. C. A.



1010. *Measurement of Projectile Velocities with the Johnsen-Rahbek Apparatus.* **K. Rottgardt.** (Zeits. techn. Physik, 4. 2. pp. 63–66, 1923.)—An apparatus made by Huth employing the Johnsen-Rahbek phenomenon is described in detail, with photographs of the finished apparatus. This has been employed to measure the velocities of rifle bullets as follows. Three frames with a peripheral winding are arranged at distances of 10 metres from each other, and each winding *via* an appropriate transformer acts upon the filament-grid circuit of a thermionic valve the plate circuit of which includes a Johnsen-Rahbek tractive apparatus giving a graphic record timed by a ½-second pendulum. On firing a rifle the circuits wound upon the frames are successively broken by the bullet, and so give interruptions upon the graphic record which are timed by the pendulum. Hence knowing the distance apart of the frames the velocity of the projectile can be calculated. The method is stated to be independent of any lag. B. J. L.

1011. *Regulating Spring Devices.* **J. Andrade.** (Comptes Rendus, 176. pp. 811–813, March 19, 1923.)—These methods are applicable to the regulation of clocks in respect of thermal changes. P. E. S.

1012. *Ball Hardness and Scleroscope Hardness.* **H. O'Neill.** (Nature, 111. pp. 430–431, March 31, 1923.)—If H_u is the ultimate Brinell hardness and S is the scleroscope hardness, the author finds that the relation $H_u = 0{\cdot}79S^{1{\cdot}44}$ holds good. W. R. C.

1013. *Permanent Deformations Produced by Compression and Tension.* **Malaval.** (Comptes Rendus, 176. pp. 488–490, Feb. 19, 1923.)—It is shown that, certainly in the case of copper, and probably generally, there is a difference (which is not greater than 7 %) between the diagrams obtained on compression and tension, a difference which is partially due to friction at the bases in the case of the specimen in compression; when circumferential hydrostatic compression is used the difference disappears if a suitable correction for friction is made. It would appear that the only factor for permanent deformation by tension or compression is the tangential component and that work hardness depends solely on the amount of slip. In a note added **Mesnager** (pp. 490–491), it is stated that these results confirm experimentally the law announced by him in 1900, but that he has found that in the case of alternating stresses the amount of work hardness produced is not the same as with uni-directional stresses, the force in one direction appearing partially to destroy the effect produced by that in the opposite direction. J. L. H.

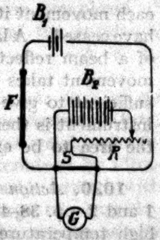
1014. *The Compressibility of Thirty Metals as a Function of Pressure and Temperature.* **P. W. Bridgman.** (Am. Acad., Proc. 58. pp. 166–242, Jan., 1923.)—This paper deals with an experimental determination of the compressibility of 30 metals over a pressure range of 12,000 kg./cm.^{2} and at 30° and 75° C., and describes a new method of measuring compressibility, involving the measurement of the difference of compressibility between the substance and pure iron. This method involved also a determination of the absolute compressibility of pure iron, the results of which are given as follows: At 30° C. $\Delta V/V_0 = -10^{-7}(5{\cdot}87 - 2{\cdot}1 \times 10^{-5}p)p$ and at 75° C. $\Delta V/V_0 = -10^{-7}(5{\cdot}93 - 2{\cdot}1 \times 10^{-5}p)p$, where V_0 is the volume under atmospheric pressure at 30° C. or 75° C., and p the pressure in kg. per square cm. The experiments were divided into two classes, namely for those metals crystallising in the cubic system, and for those not crystallising in the cubic system. In general the compressibility decreases with increasing pressure and increases with increasing temperature. The order of magnitude of the change of compressibility or thermal expansion with pressure is the same for all metals. The compressibility changes under pressure by a fraction which is a small number (varying from 2 to 30) times the proportional change of volume under the same pressure, and similarly the proportional change of thermal expansion under pressure is of the order of a small number times the corresponding proportional change of volume. Six of the 30 substances tested did not crystallise cubic or in the hexagonal close-packed arrangement of spheres, and for these it was established that there are large differences of compressibility in different directions; in the case of tellurium it was found that in one direction the linear compressibility was negative. In the theoretical discussion it is shown that it is very probable that the forces resisting compression in a metal are the same in nature as those in a salt of the type NaCl, that is, the metal may be regarded as a lattice of ions and electrons acting on each other by electrostatic forces due to one or more single elementary changes; in addition there is a repulsive force. Criticism is made of Born's proof of the inverse ninth power law for the potential of the repulsion, and it is concluded that the present knowledge of the atomic structure is insufficient to determine the law of repulsion so accurately as to allow one to differentiate the formulæ once and twice, as is necessary in computing the compressibility with its change of pressure. It is shown by numerical calculation that the effect discussed by Schottky due to the deformation of the atoms under pressure is of such an order of magnitude that it must be taken into account. It is finally shown that if the specific form of the repulsive potential is not assumed, but replaced by an arbitrary function, then the first, second, and third derivatives can be computed numerically from experimental data now available for a number of metals of this investigation. From the latter the conclusion is drawn that the boundaries of the atom cannot be as definite as appeared not unlikely from a study of the polymorphic changes under pressure. The results of the measurements are given in tabular form in this paper. [See also Abstract 1359 (1915).] A. W. J.

1015. *The Rayleigh Pendulum.* **G. Krutkow** and **V. Fock.** (Zeits. f. Physik, 13. 3. pp. 195–202, 1923.)—A mathematical treatment of the time of vibration of a pendulum of continually varying length. P. E. S.

1016. *Relation between Young's Modulus, Density, and Atomic Weight.* **T. Peczalski.** (Comptes Rendus, 176. pp. 500–502, Feb. 19, 1923.)—If there are n atoms in 1 cm. cube, there are $\sqrt[3]{n^2}$ in a single layer $\sqrt[3]{1/n}$ thick. The force between any two layers is proportional to the product of the numbers of atoms in each. The total force on each layer is also proportional to $\sqrt[3]{n^2}$ and the force between two proximate layers $\sqrt[3]{n^4}$. Hence the total force between two proximate layers for a displacement dr is: $df = n^2 \,.\, dr$. The force $d\mathrm{F}$ required to distort the whole unit cube in this way is given by: $d\mathrm{F} = \mathrm{A} \,.\, nd^2l = \mathrm{E} \,.\, dl$, where E is Young's modulus for the material. Hence $\mathrm{E} = \mathrm{A} \,.\, n^2$, and if ρ be the density and m the atomic weight, this becomes: $\mathrm{E} = \mathrm{B}(\rho/m)^2$ where B is another constant of value about 8×10^7. For compounds write $M = \Sigma kM/\Sigma k$ where M is the mass of each type of component atom and k the number of each in the molecule. The expression gives approximate values for Young's modulus for nine metals and two salts. A. Wh.

1017. *The Time Service of the Paris Observatory.* **G. Bigourdan.** (Bull. Astronomique, 2. No. 6. pp. 379–408, 1922.)

1018. *Hot-Wire Compensating Anemometer.* **Huguenard, Magnan, and A. Planiol.** (Comptes Rendus, 176. pp. 287–289, Jan. 29, 1923.)—Hot-wire anemometers are specially suitable for studying the motions of the air from the point of view of instantaneous phenomena. The best results have hitherto been obtained by a difference of potential as constant as possible at the extremities of the wire. If a galvanometer shunt be placed in the heating circuit, a difference of potential is observed at the extremities of the shunt, which increases more and more slowly with the velocity of the wind, following an approximately parabolic law. Such an apparatus is obviously limited to a very narrow range of measurement. After numerous experiments the authors have succeeded in overcoming this difficulty by replacing the shunt by a body of variable resistance. This new device should satisfy the following requirements: a resistance increasing with the current flowing through it and variations of resistance as rapid as those of the anemometric wire. These considerations have led to the employment of a metallic wire of a diameter not exceeding that of the anemometric wire. Owing to the necessity of withstanding high temperatures in contact with the air the metal chosen was platinum. After many trials the arrangement shown in the figure has been adopted as being the simplest and most efficient. A battery B_1 generates a current i which flows through and heats the anemometric wire F. The wire shunt S is inserted in this circuit, shielded from the wind by an enclosure, and having at its extremities the galvanometer G. A second battery B_2 is placed in opposition to B_1 at the extremities of S by the intermediary of an adjustable resistance R, enabling the current to be quenched when there is no wind blowing on F. The wire S has then the temperature of the surrounding medium. Supposing the resistance of R to be very great relatively to all the other resistances, which implies for B_2 a very high electromotive force, the variations in intensity i_2 of the current flowing in the direction of B_2R may be neglected when, under the influence of the variations in resistance of F owing to its cooling, the intensity of the current flowing through F will vary. Thus supposing i_2 to be constant, its value is i_0, the value of i_1 for $v = 0$. The current flowing through S will therefore be $i_1 - i_0$, and the amount of energy expended in S will be $r(i_1 - i_0)^2$, r being the resistance of the shunt S. This current will increase very rapidly when v increases with the correlative rising of the temperature of S. Experience has shown that the following rules should be observed: (1) The length of S should be such that the loss of heat at the ends of the wire does not too greatly affect the mean temperature of the whole. (2) Choose a length so short that its resistance will be small relatively to that of F, otherwise the tension at the extremities of F would fall too much when v increases. (3) Let the diameter of S



be less than that of F for the following reasons: the necessity of following the fluctuations in the temperature of F without any delay and of allowing the excess $i_m - i_0$ of the current i_m sent through F to raise S to a high temperature in order greatly to increase its resistance. With a wire F of 0·05 mm. in diameter the best results were obtained by employing for S a wire of 0·025 mm. in diameter and about 10 mm. in length. These conditions give approximately $i_0 = 0{\cdot}7^a$ for $v = 0$, and $i_1 = 1^a$ to $1{\cdot}05^a$ for $v = 15$ to $20\ m/s$. The electromotive force of battery B_2 was about 100^v, which gives for R a resistance of about 140ω. The variation in the current i_2 generated by B_2 is thus reduced to a few milliamperes and does not adversely affect the supply to S. The results so far obtained are only provisional and subject to future revision. E. F.

1019. *Measuring Apparatus for Locating Mineral Wealth.* **G. Wünsch.** (Zeits. Vereines deutsch. Ing. 67. pp. 189–190, Feb. 24, 1923.)—The Eötvös torsion balance, as developed by Schweydar, is made use of to study the variations of the gravitational field in the region to be explored. An aluminium tube is suspended horizontally by a long fine wire. A gold weight is fixed to one end, and from the other hangs a lead weight on a thread about 60 cm. long. The two weights lie on different gravitational equipotential surfaces, and if, owing to a disturbance of the field, these are inclined to one another the gravitational forces acting on the two weights will not be parallel. In certain positions this will produce a torque on the tube joining them, which will be balanced by a torque due to a twist produced in the suspending wire. This twist is measured by a photographic arrangement, the instrument being turned about its vertical axis at long intervals by a clockwork arrangement. After each movement it remains undisturbed for about an hour, until vibrations have ceased. A lamp is switched on long enough to photograph the position of a beam reflected from a mirror on the suspended part, and another movement takes place. Six movements, each through 120°, are generally sufficient to give the information required for any one station, and the instrument is then moved in turn to a number of different stations about the area to be explored. H. N. A.

1020. *Action of Radiation.* **F. Dessauer.** (Zeits. f. Physik, 12. 1 and 2. pp. 38–47, 1922.)—A working hypothesis, leading up to localised high temperatures due to electron impacts, for the action of radiation on biological tissues, photographic plates, colloids, and other substances. Comparison with observations. A. D.

1021. *Some Recent Researches on Lubrication.* **T. E. Stanton.** (Inst. Mech. Eng., Proc. No. 6. pp. 1117–1145, Dec., 1922. Ninth Thomas Hawksley Lecture.)

1022. *Mono-Molecular Films of Oleic Acid on Water.* **A. Marcelin.** (Comptes Rendus, 176. pp. 502–504, Feb. 19, 1923.)—The surface force of mono-molecular films of oleic acid on water decreases steadily to zero as the surface concentration of molecules decreases likewise. For 0·1 surface saturation the force is detectable with a delicate torsion apparatus, at 0·4 the force is of the order 0·05 dynes/cm. and increases to about 0·5 dynes/cm. at saturation. Above saturation the surface force increases to a maximum of about 30 dynes/cm. when the layer is approximately two molecules thick. The surface energy of the oleic acid molecules may be compared either with two dimensional Brownian movement or with osmotic pressure, since such a layer seems to have some of the properties associated with solutions. A. Wh.

1023. *Smokes: Part I. A Study of their Behaviour and a Method of Determining the Number of Particles they Contain.* **R. Whytlaw-Gray, J. B. Speakman,** and **J. H. P. Campbell.** (Roy. Soc., Proc. 102. pp. 600–615, Feb. 1, 1923.)—An investigation of the properties of very dilute systems of solid particles of ultra-microscopic size suspended in a gaseous medium. The dispersoids were prepared by: (1) Sudden cooling of saturated vapour by mixing with a large volume of air or gas; (2) chemical action; (3) the arc or spark discharge in air. The number of particles in a given volume of the dispersoid was obtained by counting the number seen in the field of a slit ultra-microscope, the arrangement of the apparatus being a modification of the method given by Zsigmondy. The number of visible particles per c.c. obtained in this manner has been shown to agree closely with that obtained by collecting the particles from a known small volume of cloud by subsidence, illuminating them by a strong beam of reflected light, and counting the number in the deposit. Curves between the number of particles per c.c. and age of the cloud all show an unstable initial period where the number of particles falls off very rapidly, and in which the particles show a rapid increase in size. After several hours a stable period is reached where the falling off is slow, and which continues until the cloud settles. For the non-volatile oxide smokes the growth of the particles is caused by the gradual aggregation of the smaller particles to form complexes of different structure depending on the chemical nature of the substance dispersed. A. W. L.

1024. *Smokes: Part II. A Method of Determining the Size of the Particles in Smokes.* **R. Whytlaw-Gray** and **J. B. Speakman.** (Roy. Soc., Proc. 102. pp. 615–627, Feb. 1, 1923.)—The total weight of suspended solid matter in a given volume of smoke is determined by filtration through small tubes containing asbestos previously treated with collodion in acetone to prevent loss. A point discharge of electricity produced in the filtering layer assists precipitation. The volume usually taken was 1 litre, and the time taken in filtration about 5 minutes, the increase in weight being determined with a micro-balance sensitive to 0·0002 mgm. Curves are obtained showing the weight per litre plotted against the age of the cloud, and knowing the number of particles present at different times the average mass of a particle at different periods in the age of the smoke is determined. Assuming that the particles are spheres whose density is the same as that of the substance in bulk their average radius can be found; particles whose radii are of the order of 10 $\mu\mu$ are clearly visible in the ultra-microscope. All the weight concentration curves show an increase in the early stages of the cloud which is attributed to the presence of large numbers of particles invisible in the ultra-microscope. A. W. L.

1025. *The Early Stages of a Submarine Explosion.* **H. Lamb.** (Phil. Mag. 45. pp. 257–265, Feb., 1923.)—Besant and Rayleigh

[Abstract 5 (1918)] have given the theory of the collapse of a spherical bubble in water. The cognate problem of the expansion of a spherical cavity owing to the pressure of an included gas is given in the present paper, and is of interest as being the nearest approach that can be made at present to the case of a submarine explosion. Imagine a quantity of gas liberated instantaneously in a spherical cavity in an unlimited mass of liquid, assumed in the first case to be incompressible, and the density of the gas at each instant to be uniform. It is shown that the initial acceleration of the radius is C_0^2/R_0, where $C_0 = \sqrt{(p_0/\rho)}$, C_0 being a velocity which determines the rapidity with which subsequent changes take place, R_0 the original radius of the cavity, p_0 the initial pressure of the gas, ρ the density of the liquid. If, for example, the initial pressure is 1000 atmospheres, or say $p_0 = 10^9$ c.g.s., then for water $C_0 = 3 \cdot 16 \times 10^4$. For an initial pressure of 10,000 atmospheres, $C_0 = 10^5$. Assuming Boyle's law, so that $p/p_0 = (R_0/R)^3$, $R^2/C_0^2 = 2(R_0/R)^3 \log (R/R_0)$. This gives a maximum for $\dot{R}$ when $R/R_0 = \sqrt[3]{e} = 1 \cdot 396$, this maximum being $0 \cdot 495\, C_0$. A more accurate result is obtained if instead of Boyle's law we adopt the adiabatic law of expansion, *i.e.* $p/p_0 = (R_0/R)^{3\nu}$. The maximum of $\dot{R}$ is, for example, now given by $\dot{R}^2/C_0^2 = 2/3\gamma^{\nu(\nu-1)}$. Since cooling of the gas by expansion and consequent diminution of pressure are now taken into account, the changes take place more slowly than in the previous case. Concrete illustrations are given. For example, if the initial diameter of the cavity is 1 metre, $p_0 = 1000$ atmospheres, $\rho = 1$, $C_0 = 3 \cdot 16 \times 10^4$, then the radius is doubled in 1/250 of a second, and multiplied 5-fold in about 1/30 of a second. The maximum of $\dot{R}$ occurs when $R = 4/3(R_0)$, $t = 0 \cdot 0016$ sec., and is about 145 metres per sec., or about one-tenth the velocity of sound in water. A more difficult question remains as to how far the results are modified by the compressibility of the water. With C_0 small compared with the velocity of sound-waves in the water, the effect would not be very great, but in the case of a submarine mine the velocities communicated to the adjacent water may exceed the velocity of sound. The above theory then ceases to have any very close relation with the facts. Accurate equations of motion of spherical waves in a compressible medium are given, but a solution seems at present hopeless. T. B.

1026. *The Speed of the Uniform Movement of Flame in Mixtures of the Paraffins with Air.* **W. Mason.** (Chem. Soc., J. 123. pp. 210–214, Feb., 1923.)—Accurate information was required of the compositions of the mixtures of methane, ethane, propane, butane, and pentane respectively, with air, which would yield the maximum speed of uniform movement of flame under standard conditions of experiment. Similar determinations had already been made by Payman [Abstract 399 (1920)], using the "screen-wire" method, and it was desired to check these results by means of the more accurate photographic method. A brass tube 5 cm. diameter was constructed holding a window or slit of quartz 30 cm. long, and a quartz lens was employed to focus the slit on a rapidly revolving film. The rate of revolution of the film was timed by allowing the sparks which occurred at the mercury break of an electrically operated tuning fork to focus themselves through a slit in the back of the camera, on the moving film. Tables and curves were thus constructed, coordinating the speed of the flame with the percentage of the paraffin in air. The mixtures (per cent.) in which the speed of uniform movement of flame is fastest were found to be: Methane 9·65 %, 91 cm./sec.; ethane 6·05 %, 127 cm./sec.; propane 4·45 %, 114 cm./sec.; butane 3·65 %, 113 cm./sec.; pentane 2·90 %, 115 cm./sec. T. B.

1027. *Soaring Flight of Gulls Following a Steamer.* **E. H. Hankin.** (Cambridge Phil. Soc., Proc. 21. pp. 426–429, Feb. 8, 1923.)—An account is given of numerous observations which have been made on the soaring flight of gulls. It is stated that the soarable area is usually situated in a downwardly descending current on the leeward side of the ship, and that the birds do not prefer the windward ascending current. There is also a small ascending current, immediately behind the stern, when the wind is ahead, the descending current being from 10 to 50 yards further to the leeward. The instability of flight in the soarable area is discussed, and reference is made to the results of tests made with long threads of cotton, at the stern, to determine the nature of the currents existing; it is shown by these results that the soarable area is definitely in the descending air region, and in its central part. A. W. J.

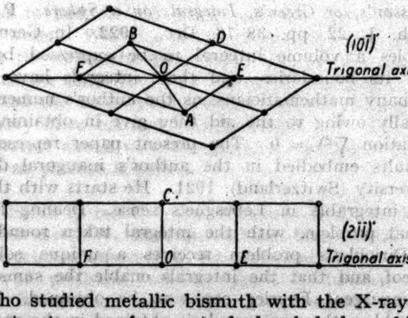
1028. *Decay of Vortex Motion on a Viscous Fluid.* **K. Terazawa.** (Aeronautical Research Inst. Tokyo Imp. Univ. 1. 4. pp. 87–134, Nov., 1922. In English.)—Contains the results of a previous paper [Abstract 2200 (1922)], together with new solutions in which a line source or sink is present. Mainly mathematical. W. G. B.

1029. *Poisson's, or Green's, Integrals on a Sphere.* **P. E. Strässle.** (Tôhoku Math. J. 22. pp. 38–76, Dec., 1922. In German.)—Green's theorem enables a volume integral to be expressed by the surface integrals over its boundaries, and these integrals have attracted the attention of many mathematicians, as the author's numerous references show, principally owing to the aid they give in obtaining solutions of Laplace's equation $\nabla^2 V = 0$. The present paper represents the more important results embodied in the author's inaugural dissertation at Freiburg University (Switzerland), 1921. He starts with the assumption that V(P) is integrable in Lebesgue's sense. Dealing first with the two-dimensional problem, with the integral taken round a circle, he shows that Dirichlet's problem receives a unique solution and a criterion thereof, and that the integrals enable the sums of divergent as well as convergent Fourier series to be obtained. In the three-dimensional problem the same result is obtained in the case of spherical harmonic series. In dealing with the behaviour of the higher derivatives of the integrals he has avoided the vast labour which would have been required for their separate calculation by first determining their behaviour where V(P) is an analytic function, and then in the general case, dividing it into an analytic part and a remainder, and showing that the latter is vanishingly small. G. W. DE T.

1030. *The Periodic System of the Elements and the Mechanical Technological Properties of Glasses.* **J. Salpeter.** (Zeits. techn. Physik, 4. 1.

pp. 36–39, 1923.)—In Sommerfeld's book "Atomic Structure and Spectral Lines," a relationship is given between compressibility, expansion coefficient, reciprocal of fusion temperature, and atomic volume of an element. The present paper deals with the elasticity and tenacity of elements in connection with their position in the periodic system, an investigation not hitherto undertaken. Amorphous substances are best for such a purpose, and, since the elements do not themselves exist in this state, the properties of glasses can be examined for such elements as occur there in the condition of their oxides. The survey is limited to the following three properties: thermal expansion coefficient and elasticities of tension and pressure. Winkelmann and Schott's results are quoted for the thermal expansion coefficients as functions of chemical composition, and the conclusion is drawn that the influence exerted by an oxide on the expansion coefficient of a glass is parallel with the position of the element in the atomic volume curve. Various discrepancies are pointed out, *e.g.* for the oxides of zinc, aluminium, and lithium, but Grenet's investigations and his data for glasses of Blanzy and St. Gobain are quoted to show that the actual connection between expansion coefficient and chemical composition of glasses, while complicated, indicates the Winkelmann-Schott exceptions to be qualitatively incorrect. Generally speaking, there is a parallel between the elasticities of elements in the form of oxides in glasses, and the exceptions as given by previous data would perhaps disappear when more exact experimental results are to hand, as in the thermal data quoted. H. H. Ho.

1031. *Crystal Structure of Bismuth.* **L. W. McKeehan.** (Frank. Inst., J. 195. pp. 59–66, Jan., 1923.)—Rhombohedral axes mutually inclined at 87° 34′ were made use of by Ogg [Abstract 1966 (1921)] and



by James, who studied metallic bismuth with the X-ray spectrometer. The units of structure are face-centred rhombohedra, which differ little from cubes. Two such lattices must be present, so situated with respect to each other that the array of points does not differ much from a simple cubic lattice. Simplicity in nomenclature, however, is attained by using rhombohedral axes, which are halves of the face diagonals of the first rhombohedron, and are therefore inclined at 57° 16′. This gives a simple rhombohedral space lattice, a fundamental type. The author shows how the data previously obtained can be transferred to the new system. The diagram shows the relative positions of the lattice points on simple planes containing the trigonal axis, and therefore common to both lattices, as calculated from $u = 0\cdot474$. The twenty lattice points nearest to any point selected, such as O, lie at the following distances:

Points on the other lattice:	3 at $3\cdot099 \times 10^{-8}$ cm. as OA.
	3 at $3\cdot465 \times 10^{-8}$ cm. as OB.
	1 at $5\cdot598 \times 10^{-8}$ cm. as OE.
	1 at $6\cdot211 \times 10^{-8}$ cm. as OF.
Points on the same lattice:	6 at $4\cdot529 \times 10^{-8}$ cm. as OC.
	6 at $4\cdot726 \times 10^{-8}$ cm. as OD.

The three valence electrons may be put between the atom pairs separated by less than $3\cdot5 \times 10^{-8}$ cm., but the stability of this arrangement has not been calculated. New measurements were made by the powder method. These seem to indicate that the atoms are not as uniformly spaced along the trigonal axis as the above parameter u would indicate.
H. N. A.

1032. *Precision Measurements of Crystals of the Alkali Halides.* **W. P. Davey.** (Phys. Rev. 21. pp. 143–161, Feb., 1923.)—The Hull powder method of obtaining X-ray diffraction patterns was used. By comparing each diffraction pattern directly with the pattern of NaCl simultaneously recorded on the other half of the film, the grating space of each crystal powder was measured in terms of the side of the unit cube of NaCl, assumed to be 2·814 Å., with a precision of about 0·1 %.

Crystal Densities.—The crystal densities of all the alkali halides are given, computed from X-ray data. The results are accurate to within about 0·3 %, and they agree, as regards the chlorides and iodides (except LiI), with those obtained by other methods within 0·2 % on the average, whereas for the others the values are higher by 0·5 to 1·5 % for the bromides and 1 to 9 % for the fluorides.
AUTHOR.

1033. *Crystal Structure of Hydrazine Dihydrochloride.* **R. W. G. Wyckoff.** (Am. J. Sci. 5. pp. 15–22, Jan., 1923.)—The methods described in previous papers by the author were employed [Abstract 1532 (1920)], both reflection spectrograms from the crystal faces and Laue photographic data being made use of. The latter show that a simple cubic lattice underlies the space group, and that there is marked hemihedry, the symmetry being that of Th^6, the paramorphic hemihedry (pyritohedry) of the cubic system. The unit cell is a cube the edges of which measure 7·89 Å., and it contains four chemical molecules. The parameter v defining the positions of the chlorine atoms is found as 0·27+, and the most probable value of the nitrogen parameter is estimated as about 0·04. The distance between adjacent chlorine atoms is approximately 3·96 Å.; between Cl and N atoms about 3·14 Å. These figures do not agree with the values previously assigned to the atomic radii of Cl and N, which would make the distance Cl to Cl 2·10 Å., and Cl to N 1·70 Å. In the diagram showing the structure as found the unit cell is shown, divided into four cubes, with the Cl atoms at or near the centres of these. A diagonal is drawn through each of the Cl atoms, in such a way that those in adjacent cubes are at right angles to one another. Two N atoms lie on each of these diagonals, at a small distance on either side of one of the corner sof the small cubes to which they belong; eight of these atoms lie outside the unit cell. The points midway between the N pairs are the centres of the $N_2H_4 . 2HCl$ molecules; so that the

unit cell as drawn contains eight half molecules, or four molecules. The positions of the H atoms are not indicated; they are considered as all equivalent to one another, and occupying the 24 most generally placed positions of Th^6. The mathematical treatment of the problem is founded on the author's paper "The Analytical Expression of the Results of the Theory of Space Groups" (Carnegie Inst. Wash., Pub. No. 318, 1922).
H. N. A.

1034. *Structure of Metal Crystals; Modified Powder Method of Analysis.* **E. A. Owen** and **G. D. Preston.** (Phys. Soc., Proc. 35. pp. 101–108, Feb., 1923.)—A description is given of a method of X-ray examination of the crystalline-structure of metal plates, using the Bragg X-ray spectrometer. Plates of aluminium, iron, copper, lead, and magnesium have been examined, employing direct radiation from a molybdenum antikathode in a Coolidge tube. To remove the deformed surface layer of the metal the plate is etched and is then smeared over with vaseline to prevent further oxidation. The results obtained are summarised in the following table:

Element.	Structure.	Length of Side of Elementary Cube (a).	Values of (a) as Measured by Hull.
Al ..	Face-centred cube	4·041 Å.	4·05 Å.
Fe ..	Centred cube	2·869	2·86
Cu ..	Face-centred cube	3·628	3·60
Pb ..	Face-centred cube	4·983	4·92

The wave-lengths of the radiation employed are $\lambda_a = 0\cdot711$ Å. and $\lambda_\beta = 0\cdot629$ Å.

Special procedure was necessary in the case of magnesium (hexagonal lattice) in order to include crystals of different axial ratios. Of the 22 lines in its spectrum, 18 were α-lines, these being used to calculate the axial ratio—giving a mean value of 1·631. The mean value of the length of the side of the magnesium hexagon was found to be 3·17 Å. A. B. W.

1035. *The Relation between Molecular and Crystal Symmetry as Shown by X-Ray Crystal Analysis.* **G. Shearer.** (Phys. Soc., Proc. 35. pp. 81–98; Disc., 98–100, Feb., 1923.)—The symmetry number is the number of asymmetric molecules per cell required to produce the symmetry of the class, or a multiple of this; it is postulated that the symmetry of a symmetrical molecule is, in general, part of the symmetry of the crystal; the symmetry number of the crystal may be found by multiplying the symmetry number of the molecule by the number of the molecules in the cell. Several crystals are discussed from this point of view, in particular the ruby and quartz. The former is ditrigonal scalenohedral, which requires 12 asymmetric molecules per cell. If the two Al atoms of Al_2O_3 are placed along the trigonal axis, and the oxygens at the corners of an equilateral triangle in the equatorial plane of the two aluminiums, a highly symmetrical molecule is formed. Two such molecules in the unit cell, arranged so that the second is a mirror image of the first in a plane of symmetry bisecting the angle between two of the digonal axes of the molecule, would give a crystal of the dihexagonal bipyramidal class; the conclusion is that the aluminium molecule has not the full symmetry ascribed to it above, and that it is not possible to consider the various atoms as spheres. The deciding factor in the determination of the symmetry must be the distribution of the outer electrons in the component atoms. A discussion of KCl seems to show that K and Cl atoms are interchangeable, as far as symmetry is concerned. We have to deal with K^+ and Cl^- and each ion has the electron arrangement of argon in the outer shell. Even in the case of NaCl, where Na^+ has the electron arrangement of neon while Cl^- has that of argon, it appears that, for crystallographic purposes, the two ions may be regarded as identical. This question is considered in the light of Bohr's theory, and it is concluded that two such atoms placed end to end in opposite directions give a molecule with the symmetry of the NaCl molecule. If the lower atom of the molecule is rotated through some angle about the trigonal axis, the molecule has the symmetry of the KCl molecule. A number of organic crystals are considered in the light of the theory; and in the case of benzene it is found that the Dewar formula gives a molecule with the required symmetry. *Discussion.*—**J. W. Evans** thought the explanation of the structure of KCl was not convincing, and that the symmetry shown was that of quartz. The author explained that there are four KCl molecules in the unit cell; and the observed symmetry is due to the combination of the molecular symmetry and that due to their arrangement in the cell. H. N. A.

1036. *Relation between the Crystal Structure and the Constitution of Carbon Compounds. Part I. Compounds of the Type CX_4.* **I. E. Knaggs.** (Chem. Soc., J. 123. pp. 71–79, Jan., 1923.)—The crystal form is determined by optical methods for a number of crystals of the above constitution and compared with that which appears probable on the space group theory. Where X represents a single atom, the crystals generally belong to the cubic system, though in some cases at low temperatures there is a transition to doubly refracting crystals. It is shown by means of diagrams that compounds of the type $C(CY_2Z)_4$ may be expected to crystallise in one of the classes of the tetragonal system [Fig. 2 in the original paper is slightly misleading, as it is printed upside down]; this is confirmed by optical measurements for several compounds. H. N. A.

1037. *Structure of Benzene.* **M. L. Huggins.** (Am. Chem. Soc., J. 45. pp. 264–278, Feb., 1923.)—The author considers the probable positions of the four valence electrons round each atomic centre in the graphite structure found by Debye and Scherrer [Abstract 1140 (1917)]. In this structure the atoms are in layers, in which they are arranged in hexagonal form, the layers, according to Hull, being "puckered." The author considers that this puckering is due to the apices of alternate tetrahedral atoms pointing in opposite directions (up and down) on either side of each layer. The upward pointing tetrahedra of one layer are connected to the downward pointing ones of the layer above, which are vertically above them, by an electron pair [Abstract 275 (1923)], while there is a sextet of electrons around the centre of each hexagon within each layer. The arrangement of the layers suggested by Hull is regarded as impossible. Considering the electron sextets as the major scattering centres; and the kernel electrons, and the electron pairs between the layers, as minor scattering centres, the interplanar distances to which X-ray spectrum lines should correspond are the same as for the structure given by Hull on the basis of atomic centre scattering. The relative intensities from the two structures should be nearly the same. A number of benzene derivatives are investigated on the assumption that the carbon atoms are arranged hexagonally as above; and a table shows the calculated dimensions of the hexagons, as deduced from the axial ratios and the densities; these dimensions agree quite well with one another and with those of the graphite hexagon; the hexagons tend to form close packed layers resembling those in the graphite structure. Diagrams are given showing how the elements H, Cl, or radicles such as OH, are attached to the carbon atoms for some of these compounds, while interesting patterns are shown for the possible arrangement of triphenyl units in close packed or semi-close packed layers. H. N. A.

1038. *The Crystalline Structure and Properties of Tartaric Acid.* **W. T. Astbury.** (Roy. Soc., Proc. 102. pp. 506–528, Feb. 1, 1923.)—Observations were made on dextro-tartaric acid with the Bragg ionisation spectrometer; the number of molecules per cell was calculated from the observations as 2·006, and, taking this as two, the values of *a*, *b*, and *c* were found to be 7·693 Å.U., 6·037 Å.U., and 6·195 Å.U. Calculations and observations of the spacings were made for six important planes; the agreement was good for 100, 011, 110, and $\bar{1}01$, but for 010 and 001 the observed values were half the calculated. Starting from this fact it is concluded that the units are unsymmetrical, the molecules at the corners of the cell point in one direction, and somewhere on the line parallel to *a* joining the centres of the faces of the cell is a similar molecule, pointing in the opposite direction, but neither at the centre of the face or at the centre of the cell. This involves a unique dyad [or digonal] axis, parallel to the crystallographic axis *b*, for the completed structure; which is monoclinic spheroidal: $\beta = 100° 17'$. A careful study of the accepted structural formula for tartaric acid, showing how the various atoms may be arranged in space, so as to give two molecules

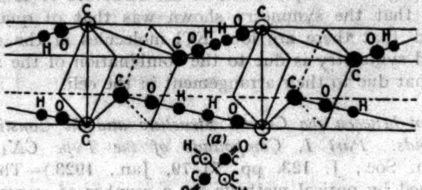


FIG. 1.

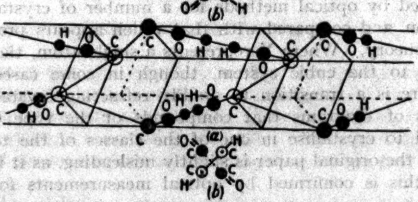


FIG. 2.

which are the mirror images of one another; and a third molecule without twist to represent the internally compensated meso-tartaric acid; a study of the intensity of reflection in the first four orders for six important planes of the crystal; and the adoption of dimensions for the atoms involved derived from the work of W. H. and W. L. Bragg, lead step by step to a structure which agrees remarkably well with the measurements, and explains the cleavage of the crystal. This takes place in the planes where the bonds of union are between two H atoms of two hydroxyls. Fig. 1 shows the structure arrived at for dextro-tartaric acid, while Fig. 2 shows that for lævo-tartaric acid. Four lines of molecules as indicated in Fig. 1 (*a*) are arranged so that the axes of the structures shown coincide with the four edges of the unit cell parallel to the *a* axis of the crystal. An exactly similar structure, reversed in direction, passes parallel to the above four through the centre of the cell, its relative position being such that the hydrogen and oxygen atoms shown in Fig. 1 (*b*), which form part of the molecule, link up with the oxygen and hydrogen atoms of the adjacent molecules, and bind the structure strongly together. It will be seen that the atoms are arranged in irregular spirals, which twist in one direction in Fig. 1, and in the opposite in Fig. 2. H. N. A.

1039. *Position of the Atoms in the Optically Active Crystals $NaClO_3$ and $NaBrO_3$.* **L. Vegard.** (Zeits. f. Physik, 12. 5. pp. 289–303, 1922.) —$NaClO_3$ and $NaBrO_3$ crystals belong to the tetragonal pentagonal dodecahedral class of the cubic system. Lead nitrate and the water-free nitrates of the alkaline earths belong to the same class. Bragg's method and Debye's powder method have both been employed. The results with the nitrates have already been published [Abstract 10 (1923)]. Five parameters were needed for the chlorates and the calculation was difficult; but it was carried out systematically until an arrangement was found which gave calculated values for the intensities of reflection which agree well with those observed; this is shown in a series of diagrams, in which the intensities as observed and as calculated are indicated by the lengths of vertical lines for a large number of planes, $h_1\ h_2\ h_3$ of the lattice; a similar pair of diagrams shows that the arrangement of atoms proposed by Kolkmeijer, Bijvoet, and Korssen does not

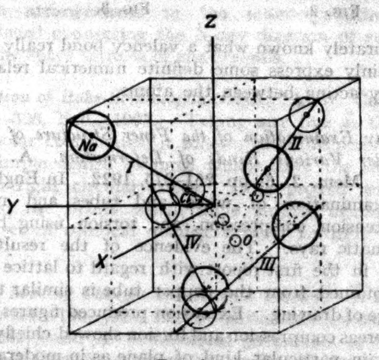


FIG. 1.

give satisfactory agreement. Fig. 1 shows the arrangement of atoms arrived at; Fig. 2 the structure of what the author supposes to represent the molecule of $NaBrO_3$. It will be seen that the Na and Br atoms are not in contact with one another. The oxygens touch one another, and are in contact with the Na atoms of three other molecules. Fig. 3 is a dissected view of the relations of these atoms for $NaClO_3$. The centres of the three oxygens and of the halogen element form a pyramid; and owing to the position of the three sodium atoms this pyramid is somewhat twisted about the axis of the molecule, either to the right or the left, and this turning is doubtless connected with the optical properties of the crystals. There is no such turning in the optically inactive nitrates. The author calls attention to the difficulty of explaining his results on the ordinary valency theory; the question of the transfer of the chemical constitution formula to the solid state is not a definite problem as long as it is not accurately known what a valency bond really is; the valency "forces" certainly express some definite numerical relations; but not the forces really acting between the atoms. H. N. A.

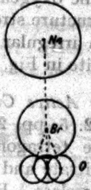


FIG. 2.

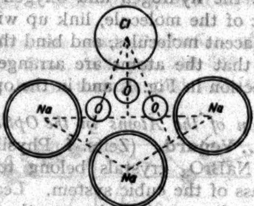


FIG. 3.

1040. *X-Ray Examination of the Finer Structure of Strained Metals. II. Copper under Various Kinds of Deformation.* **A. Ono.** (Kyushu Univ. Coll. Eng., Mem. 2. 6. pp. 261–275, 1922. In English.)—Describes the X-ray examination of wires and tubes and rods of copper strained by extension, compression, and torsion, using both white rays and monochromatic rays. The evidence of the results supports the inference made in the first report with regard to lattice re-arrangement. The pattern obtained from the copper tube is similar to that of a wire in the early stage of drawing. Extension produced figures similar to hard-drawn wire, whereas compression and torsion showed chiefly the re-arrangement of a certain particular kind of plane as in moderately drawn wire [see Abstract 396 (1923)]. J. L. H.

1041. *Compressibility, Internal Pressure, and Atomic Magnitudes.* **T. W. Richards.** (Am. Chem. Soc., J. 45. pp. 422–437, Feb., 1923.)—The author has in previous papers ascribed the changes of volume which take place when solids or liquids combine to form solid or liquid compounds, to internal pressures produced by the chemical attractions between the molecules, the latter resisting compression in varying degree [Abstract 468 (1922)]. In the present paper he makes use of Bridgman's most recent work on the compressibility of 30 metals over a range of 12,000 atmospheres, and finds that it is possible to combine the curves of different substances together, so as to carry them in some cases far beyond the experimental limits for the particular substances. Sodium, which is much less compressible than potassium, is regarded as starting with a very much greater internal pressure than the latter metal. It is found that by assuming the difference between the internal pressures to be 18,000 atmospheres, and that the volume of K is reduced to 0·67 of its original value by this pressure, the curves of these metals can be fitted together, so that it is possible by extrapolation to estimate the volume of K up to 45,000 atmospheres. The curve conforms rather closely to the simple formula $(V - B)(p + P) = C$; or a portion B of the volume acts as if it were relatively incompressible and the relation of total pressure, external plus internal, to volume is simply hyperbolical. A similar elongated curve is obtained for liquid chlorine by combining the curves of phosphorus trichloride, Br and I. It is deduced that the internal pressure in KCl is 65,000 kg./sq. cm., and the compressibility about $6 \cdot 3 \times 10^{-6}$, which agrees fairly well with the observed value. The atomic diameter of K in KCl is calculated as 3·46 Å, and that of Cl as 2·82 Å. Values are also obtained for K and Br in KBr and for Na, Cl and Br in NaCl and NaBr. H. N. A.

1042. *X-Ray Measurement of Statistical Anisotropy in Crystalline Media.* **K. Weissenberg.** (Ann. d. Physik, 69. 6. pp. 409–435, Dec. 19, 1922.)—The author deals with anisotropic crystalline aggregates of naturally occurring phases (plastically deformed metals, electrolytic deposits, etc.), and shows that they can be dealt with statistically, assuming certain arrangements in the microcrystalline aggregates. Formulæ are deduced connecting the X-ray diagram of such crystalline aggregates with the space lattices of the crystals. A. B. W.

1043. *Orientation of Bohr-Sommerfeld Orbits.* **A. W. Conway.** (Phil. Mag. 45. pp. 324–326, Feb., 1923.)—Taking any line as the Z axis and using the usual polar coordinates, it follows that the plane of all elliptic orbits about a simple centre of force which have the same azimuthal numbers, envelop right circular cones. It is proved that by taking other coordinates, the orbits which have similar azimuthal numbers touch any given set of confocal quadric cones. Entirely mathematical. A. Wh.

1044. *Pair of Moving Charges and Atomic Theory.* **S. Boguslawski.** (Phil. Mag. 45. pp. 145–160, Jan., 1923.)—Investigations by C. G. Darwin [Abstract 838 (1913)] and A. Sommerfeld [Atombau u. Spektrallinien, 2nd edition (1921), p. 324] have shown that spiral trajectories of electrons about the nucleus were to be expected under certain conditions, owing to their mass variation with speed. But there is no experimental evidence confirming the existence of such orbits. Both authors consider the central charge as fixed in space, but this is approximately true only when the central charge is of mass large relatively to that of the electron, and this condition ceases to be fulfilled from a certain moment at which the electron is approaching the central nucleus in a spiral trajectory. As the distance between them decreases, the velocity and mass of the moving charge must both increase, so that the latter may become comparable with that of the central charge. When this occurs, moreover, the distance between the charges will be comparable with the diameter of the electron, and our knowledge of the dynamics of any masses becomes uncertain. As far as experience of the scattering of α-rays goes, Coulomb's law seems to hold good even for distances of this order. But Rutherford's recent experiments on the production of H-rays by collision of α-particles with atoms point to this law ceasing to be true.

Under these circumstances it seems worth while to seek the correct solution of the idealised problem. The method chosen is by way of the Hamilton-Jacobi equation for two charges with masses varying according to Einstein's law, which is easily solved for the case of zero momentum of the system, and the result is obtained in a form to which the principles of the quantum theory can be applied immediately. The exact solution shows that, if there is attraction for small values of relative angular momentum, the relative trajectory is a spiral, as in case of a fixed centre. The critical value of the angular momentum is half of its value in the latter case. For practical purposes the approximate solution suffices, obtained by assuming the kinetic energy of the system small compared with the energy stored in the masses. The explicit equations of the trajectories are then the same as for a fixed centre, only the constants of the equation being different. The effect of this modification on the H or He spectrum is too small to be observed. The same method is then applied to investigate the magnetic forces arising from the mutual displacement of charges in the atom, confining attention to quasi-stationary movements of the charges, so that the time required for the propagation of the electromagnetic disturbance from one charge to the other may be neglected. The shifting effect of the magnetic action in the case of a H-atom is **1/230** of the relativity effect, and for the splitting effect the ratio is **1/460**. The effect of magnetic forces is to increase slightly the relativity effect, which latter is slightly decreased by the fact that the nucleus is not fixed, as was assumed in Sommerfeld's theory. The correction is of the same order as the one just computed, so that the two corrections partly cancel each other. In atoms containing larger numbers of electrons it is probable that the magnetic forces cannot be neglected. D. Roschdestvensky and G. Krutkow [Verhandlungen des Optischen Instituts in Petersburg, Berlin, 1921], and independently the author, some two years ago, came to the conclusion that they account for the doublets in the arc spectra of alkali metals. Sommerfeld [Atombau u. Spektrallinien, 3rd edition (1922)] gives a theory of doublets and triplets based on the same idea. G. W. de T.

1045. *Magnetic Valency and the Radiation Theory of Chemical Reaction.* **F. T. Peirce.** (Phil. Mag. 45. pp. 317–323, Feb., 1923. Paper read before the Manchester Lit. and Phil. Soc., Nov., 1921.)—Two possible types of magnetic bond between atoms are recognised. The magnetic systems are either due to ring, vortical, or orbital electrons. In one type the bonded magnetons are coaxial and have their poles similarly oriented, in the other they are parallel and opposed. Neither type is influenced by an external electrostatic field, but a magnetic field perpendicular to a plane containing the axes of the magnetons, deforms them. A field of suitable frequency induces resonance till similar poles are approached and the bond becomes unstable and is ruptured by the repulsion. Thus dissociation is influenced by suitable radiation while combination is not. When several processes are subsequent, the total velocity of reaction is governed mainly by that of the first stage, so long

as the later stages are much faster. The case of hydrolysis of saccharose by HCl urged by Lindemann as contrary to the radiation theory, is of this type, the primary action being the formation of an unstable compound followed by its rapid dissociation. Cases where the primary reaction is a dissociation are influenced by radiation according to theory.
A. Wh.

1046. *General Principle of Relativity Applied to the Rutherford-Bohr Atom-Model.* **T. Wereide.** (Phys. Rev. 21. pp. 391–396, April, 1923.)—In this atom the possible electron orbits are determined according to mechanical principles, then the actual orbits are selected by the quantum conditions. In computing the possible orbits, Bohr assumed classical mechanics, Sommerfeld applied the special theory of relativity with marked success, and now his assumptions are further generalised. In the expression for the world line element ds in polar coordinates, the potential functions γ and γ' are put equal to $(1 + a\kappa/r + b\kappa^2/r^2)$ and $(1 + a'\kappa/r)$ respectively, where κ is the ratio of potential energy to mass. The quantum assumptions are the same as Sommerfeld's, with generalised ds, with an additional alternative assumption that the radial expression involves γ'. These lead to expressions for the energy in which all the constants are known from experimental results, except B which Sommerfeld puts equal to 1/4, but which has not yet been experimentally determined. The method here used for the atom is the same as Eddington used for a macrocosmos.
AUTHOR.

1047. *The Gravitation of Systems according to Einstein.* **H. C. Levinson, E. Picard.** (Comptes Rendus, 176. pp. 234–236, and pp. 236–237, Jan. 22, 1923.)—Levinson shows how the value of ds^2 may be expressed in terms of four variables in the case of n points moving in any arbitrary manner. The ten equations, $G_{\mu\nu} = 0$ of the gravitational field are resolved by means of boundary conditions referring to $n - 1$ points in arbitrary motion; n different expressions for ds^2, each containing 4 independent variables, and 4 $(n-1)$ dependent variables are thus obtained. These lead to $4n$ equations of motion between the $4n$ variables and s, which enable ds^2 to be expressed in terms of 4 independent variables. Picard directs attention to the work of Haag and of Le Roux on this subject, and expresses the opinion that scepticism as to the practical value and importance of the theory of relativity appears to be justified to some extent.
J. S. G. T.

1048. *Gravitational Deflection of Light.* **J. Larmor.** (Phil. Mag. 45. pp. 243–256, Jan., 1923.)—Using the Minkowskian fourfold frame of reference we have an expression for action $= \int v\,ds$, where v depends on mass and $ds^2 = c^2dt^2 - dx^2 - dy^2 - dz^2$. If this be expended in a series to bring it into line with familiar forms in dynamics, we obtain an expression which when interpreted into a Newtonian frame of x, y, z and free t approximates to Hamiltonian free action $\int T\,dt$ where $T = \frac{1}{2}mv^2$. Hence $v = -cm$. If the particle in question move in a field of potential (energy) u per unit mass, we obtain with sufficient approximation a form

$$c' = c\left(1 + \frac{u}{c^2}\right)$$

This result carries the suggestion that gravitation can be pressed into the Minkowskian electrodynamic fourfold. Thus, by slight local change in the velocity of light proportional to the potential at each place, we can insert gravitation or any other field of force into the electrodynamic scheme, itself slightly modified thereby. The next step in this order of tentative development involves the discussion of the action of a system constituted of two masses. Here we have to deal with a field of which one mass m_1 is the nucleus and whose field surrounds another mass m_2 and vice versa. It is an essential of this order of ideas, as here developed, that the action is located in the field alone and is thus expressed in a fourfold integral, which must be invariant for transformations within the group of frames, all expressing by different coordinates the same spatial spread. By thus developing the dynamical method through analysis of the action, the author concludes that the deviation of the rays of light when passing near matter should be reduced to half the value found by Einstein. P. E. S.

1049. *Can Gravitation be Absorbed into the Frame of Space and Time?* **J. Larmor.** (Cambridge Phil. Soc., Proc. 21. pp. 414–420, Feb. 8, 1923.) —It has been shown possible, as regards the main overt effect, to absorb gravitation into a scheme of moving space and time. Its complete absorption, as in Einstein's hypothesis the "principle of equivalence," would imply that bodies and the rays by which we trace them are mere projectiles traversing space, otherwise empty—a hard saying in face of the developed science of optics and electrics. It has been suggested, now for a considerable time, that the only adequate test of the coherence of Einstein's scheme is its coming into line with the principle of minimal action, and it can hardly demand a more lenient test. The answer has had to be made that in this ultimate domain the finality of any such principle cannot be recognised. It remained open then to construct, for comparison, a theory mathematically cognate founded on the principle of action. This the author has done [see preceding Abstract], with the result of finding discrepancies which raise the question whether there can be any contradiction lurking in the successive adaptations of a purely spatial formulation; for Einstein's formulation was built up tentatively by tensorial adaptations, while the author's is not amenable to any adaptation except the fundamental one to Kepler's laws of planetary motion. Recent criticisms by J. Le Roux [Abstract 820 (1923)] seem to shed decisive light on this question, for their destructive criticism of any purely spatial scheme seems to be fundamental and complete. In the dynamical procedure by action: Each configuration of the orbits of n bodies determines a four-fold expanse in which they exist: the total action is determined as a line integration in this expanse along them; then the configuration is to be varied so as to minimise this action; but Le Roux's criticism shows that it is not implied at all that the ds^2 for the varied configuration continues to belong to the same spatial expanse. It is, the author says, "the presence of a pervading medium alone, whether as the arena of dynamical action or the spatial seat of formal tensors, a medium for which the particles are essential singularities in its structure, that retains the problem always as one of a four-fold extension, instead of one in a $3n$-fold variational extension, as counting of the orbital variables would indicate. And it is the slowness of the motions of the celestial bodies compared with the velocity of adjustment by waves across the medium, that permits of an analysis attributing to each body a statical field of force and so renders practical discussion of inter-related orbits feasible. These conclusions do not involve the becoming derelict of the beautiful mathematical theory of general relativity. But the inference lies that the scheme which would absorb gravitation, and even electric fields, into a physical space and time belonging to the masses, such space being otherwise mere emptiness, has been founded on a faulty analysis inconsistent with itself. The misfit appears to arise when it is attempted to bring it into contact with the ordinary material world, with fields of activity produced by atoms. The elegant mathematical analysis of fields would still provide an effective method of exploring the inner connections of a field of gravitation with the other primary physical agencies; and if, as is here claimed, closer scrutiny compels a reversion to the view that space is a *plenum*, is an æther in the historical and ultimate British sense held ever since Maxwell and even long ago by MacCullagh, not a crude material substance but a coherent scheme of local physical relations, then further mathematical and observational development may have gained rather than lost in interest. G. W. DE T.

1050. *Theory of Gravitation.* **L. Décombe.** (Comptes Rendus, 176. pp. 292–294, Jan. 29, 1923.)—The action of gravitation may be referred to the different electric effects of the equal charges in the neutral atom. The nucleus (+) charge is supposed stationary at the centre. The orbital charges (−) are in motion. The author considers that the greater part of the action of gravitation must be referred to the nucleus—but speculation is futile, as we know so little of the nuclear properties. The author derives his views direct from the old law of Ampère, whereas the similar results recently found by A. Crehore are based on relativity theory. P. E. S.

1051. *The Gravitational Field in Empty Space.* **K. Ogura.** (Tôhuku Math. J. 22. pp. 14–37, Dec., 1922. In French.)—The paper develops a method of integrating Einstein's equations for a static gravitation field; investigates the conditions of its applicability; derives some extensions of Liouville's theorem; thereby makes an extension to a non-static space-time in which the coordinates form a *rectified reference system* in Kottler's sense [see Abstract 1213 (1918)]. Finally, the author derives and discusses the differential equations of light rays in a static field in relation to Painlevé's *natural groups* of trajectories having constant energy [see Journal de Liouville, 4th sec., 10. p. 5 (1894)]. Parts of the paper have been published previously in the Comptes Rendus. [See Abstract 27 (1922).] G. W. DE T.

1052. *Einstein Gravitation Problems.* **K. Lanczos.** (Phys. Zeits. 23. pp. 537–543, Dec. 15, 1922.)—(1) The author attempts to solve the problem of finding a unifying coordinate system for the Einstein gravitation equations. For an infinitely weak gravitation field such a system can be found, satisfying the conditions $\partial g_{is}/\partial x_s - \partial g_{ss}/2\partial x_i = 0 \ldots (1)$. Then for each g_{ik} the real and imaginary terms of the field equations give respectively the wave equation and potential equation. He claims that the fact that the second order derivatives disappear from the curvature components when the above conditions are satisfied warrants the assumption that a solution exists. He then takes the covariant group of curvature components R_{ik}, finds the conditions that the sum of the second order terms should vanish to be given by the equations $\partial\sqrt{g}g^{is}/\partial x_s = 0 \ldots (2)$, assumes coordinates fulfilling these conditions, and proceeds to transform R_{ik}, by a procedure which he claims to be "practically" justified, in such manner that the second order terms are included in a term $\Box g_{ik}$, and have so become a function of g_{ik} only. It is then shown that for an infinitesimal field, the systems of equations (1) and (2) become identical, owing to the second order terms becoming negligible, so that $g_{ik} = \eta_i^k + \gamma_{ik}$, where η_i^k is the mixed unit tensor, and γ_{ik} are the negligible terms. The author then considers the static, spherically symmetrical, gravitation field surrounding a material particle referred to coordinates of the type under consideration. Their character is unchanged by a transformation of the radius vector, $\bar{r} = f(r)$. Therefore, the coordinate system is determinable up to an arbitrary function, which can be uniquely determined by (2). In virtue of the spherical symmetry it may then be assumed that $\sqrt{g}g^{ik} = P\eta_i^k + Qx_ix_k (i, k = 1, 2, 3,)$, when P and Q are functions of r. The conditions then give $r^2\partial P/\partial r + \partial(r^4Q)/\partial r = 0$. One of the constants, owing to the self-transformation, merely fixes the unit of mass, so that for very great values of r, $f(r) = r + \frac{a}{2} + \frac{c}{r^2}\left(1 + \frac{3}{2}\frac{a^2}{r^2} - \frac{16}{9}\frac{c}{r^3} + \ldots\right)$, where a is the constant fixing the mass, and c is an arbitrary constant. Then, for $c \neq 0$, a vanishes with r, giving as the only solution satisfying the conditions a transformation into a Euclidean space in which no matter is present. Since this involves the normal form with constant coefficients, it would seem permissible to reject it, and take $c = 0$ as the only possibility of the existence of the coordinate system sought for.

(2) The author refers to the well-known extraordinary conclusions resulting from the interpretation of the singularity in the ds^2 of de Sitter's spherical world as indicating the existence of matter, of which it would otherwise be empty. [See also Eddington's Mathematical Theory of Relativity, pp. 165–166.] He deduces some further extraordinary conclusions resulting from such interpretation from a tensor calculus investigation in which his own assumption, in (1), is made. G. W. DE T.

1053. *Simple Derivation of Lorentz Transformation.* **H. M. Dadourian.** (Phil. Mag. 45. pp. 238–240, Jan., 1923.)—The author considers the x coordinates, x and x' of a point P referred to two sets of rectangular axes in uniform relative motion v along OX, the terms t and t' being measured from the instant at which O and O′ coincide. Then $x = vt + O'P$. But for space a homogeneous continuum, the value of O′P obtained from the measuring instruments in the first system is proportional to that obtained by the instruments in the second system. Hence, $x = vt + kx' \ldots (1)$, where $k = f(v)$. Similarly, $x' = v't' + k'x$. Then from the first postulate of the restricted relativity theory $v' = -v$, and, the order of points in space is not affected by a change of point of view, so that k and k' have the same sign. Again, the length of a rod in the first system has the same value when observed from the second system as when the conditions are reversed. Hence, $k = k'$, and $x' = -vt + kx \ldots (2)$. From (1) and (2)

$$x = (x' + vt') \ldots (3) \qquad t = \left\{t' + x'(1 - k^2)/v\right\}/k \ldots (4)$$
$$x' = (x - vt)/k \ldots (5) \qquad t' = \left\{t - x(1 - k^2)/v\right\}/k \ldots (6)$$

To determine k, apply the second postulate of the restricted theory to the special event—A beam of light leaves the common origin when $t' = t = 0$, and reaches a point P_1 at the instant the position of P is considered. Then, $x_1 = ct \ldots (7)$ $x'_1 = ct'_1 \ldots (8)$. Combining (7) and (8) with (3) and (5), after introducing subscripts into the latter to indicate the special event, we obtain $x_1 = x'_1(1 + v/c)/k$ and $x'_1 = (1 - v/c)/k$, giving $k = \sqrt{1 - v^2/c^2}$. Introducing this value of k in equations (3) to (6) we obtain the transformation formulæ. G. W. DE T.

1054. *Relativity Clocks and Measuring Rods.* **C. H. Bickerdike.** (Phil. Mag. 45. pp. 327–335, Feb., 1923.)—The author convicts, by quotations, even such experts as Einstein and Eddington, of confusing the minds of readers of their popular writings on relativity, by the use of language naturally interpretable as ascribing physical reality to the supposed behaviour of the purely conventional contracting measuring rods and compensating clocks assumed for the purpose of popular explanation. G. W. DE T.

1055. *The Problem of N Bodies and the Theory of Relativity.* **J. Haag.** (Comptes Rendus, 176. pp. 163–166, Jan. 15, 1923.)—The forces on each body can be expressed as those on the Newtonian system and two correction terms due to each of the other $n - 1$ bodies. The nature and magnitude of these is discussed and the validity of the conclusions examined. A. Wh.

1056. *Spectra of Double Stars and the Theory of Relativity.* **G. Sagnac.** (Comptes Rendus, 176. pp. 161–163, Jan. 15, 1923.)—The semi-annual variation of stellar spectra according to the Fizeau effect appears to imply an anisotropy in the velocity of light round a moving observer, and is incompatible with the theory of general relativity. So also is the constancy of the times of revolutions of double stars, despite the radial velocity component due to the earth and the intense gravitational field round the stars. A. Wh.

1057. *The Temporal Genesis Arrangement.* **K. Lewin.** (Zeits. f. Physik, 13. 1 and 2. pp. 62–81, 1923.)—The relativity theory requires light signals for the determination of time relations, especially for the fundamental idea of equal time intervals, and depends therefore upon the special properties and dimensional relations (constants) of a definite kind of physical procedure (light). The time arrangement so obtained is relative in the sense of its dependence on the system of reference chosen, and remains undetermined without acceptance of a concrete system of reference. Nevertheless, there are world points which are independent of such reference to a definite coordinate system, and a system of world lines has been developed by Minkowski termed by Born an absolute system of reference. It is characteristic for these world lines that the reference of a concrete object to a definite world line depends solely on existential relations. The origin relation is termed the Genesis series, and the attempt is now made to find whether a time arrangement can be evolved which depends only on the existential relations within the Genesis series, *i.e.* possesses a purely topological character. Part I considers the propositions of the time Genesis arrangement; Sections 1 and 2 dealing with the time order in the 2 types of

Genesis series. Part II deals with the determination of time by means of the Genesis arrangement; Section 1, considering the scope of the time arrangement; Section 2, discussing the idea of time itself; Section 3, investigating the uniqueness of the time determinations in the temporal Genesis arrangement; and Section 4, deriving the degree of accuracy of the time determination. A very long summary of the topological and metrical time arrangements concludes the paper. H. H. Ho.

1058. *Climatological Data, West Indies and Caribbean Service.* **O. L. Fassig.** (Climatological Data, U.S. Dept. of Agriculture, Weather Bureau, 2. Nos. 2–7. pp. 9–56, 1922.)

1059. *Notion of Phase in the Study of Pressure Waves in the Atmosphere.* **P. Wehrlé** and **R. Cordebas.** (Comptes Rendus, 176. pp. 324–327, Jan. 29, 1923.)—Successive weather charts often show certain regions persisting for a time as areas of little pressure change (centres of action), while the intermediate zone is one of lively pressure activity (the Polar Front of Bjerknes). During such a régime positive and negative "noyaux des variations barométriques" [see Abstract 1014 (1921)] pass alternately along the disturbed zone, constituting what the authors term a "wave of variation." In consequence of the finite length of the interval Δ used in constructing the isallobaric charts there is a difference of phase (*a*) between the "waves of variation" for different intervals, say Δ and Δ', and (*b*) between a "wave of variation" and the actual corresponding "pressure wave." In (*a*) the phase-difference is $(\Delta' - \Delta)/2$, supposing $\Delta' > \Delta$, and is independent of the period, T, of the pressure wave. For example, the "noyaux" for interval $\Delta = 24$ hours, arrive at any point 12 hours after the corresponding ones for tendencies ($\Delta = 3$ hours). Under (*b*) the phase-difference is $(2\Delta - T)/4$. Here, for example, when Δ is a half-period, the wave of variation is in phase with the pressure wave.

This paper is put forward as a connecting link between the French work on "noyaux des variations" and the Norwegian work on the propagation of "lines of discontinuity." Also it is held to provide an interpretation of some of Guilbert's rules. M. A. G.

1060. *Undulatory Movements of the Atmosphere and their Utilisation in Aviation Without a Motor.* **A. Baldit.** (Comptes Rendus, 176. pp. 120–122, Jan. 8, 1923.)—Investigation of upper air soundings made during the war has enabled the author to identify a number of cases in which undulatory motions, with large amplitude and of a long period, have passed over a station undetected from surface observations. For pilot balloon observations taken by the single theodolite method the upward velocities of the air may be approximately determined from any abnormal values of the horizontal wind. An ascent at Châlons-sur-Marne on May 31, 1918, with a clear sky and mean wind between the surface and 9 km. of 10 m./s. from around N.E., showed the following vertical motions: (1) Downwards with a maximum velocity of 3 m./s., between the ground and 1 km. (2) Approximately none between 1 km. and 1·8 km. (3) Upwards with a maximum velocity of 3 m./s. between 1·8 km. and 3 km. The trajectory of the balloon, found by combining the horizontal and vertical velocities, shows that it has passed through a wave moving less quickly than itself. The most favourable condition for these motions to occur over France seems to be when an anti-cyclone is situated over the

British Isles. These undulatory movements are occasionally accompanied by motion of the isotherms from north to south, which suggests that they may be caused by the advance of a mass of cold air from high latitudes.
A. W. L.

1061. *Laws of Variation of the Characteristics of Standard Air with the Altitude.* **R. Soreau.** (Comptes Rendus, 176. pp. 290–292, Jan. 29, 1923.)—Measurements taken at great heights still fall short of the desired accuracy, especially as regards temperature. The author's method, which dispenses with a knowledge of the values of t, is therefore eminently suitable for the study of the upper atmosphere. To obtain sufficiently correct means, all the bulletins of the International Commission, from Jan. 1, 1904, to July 1, 1912, were consulted. The mean pressures for each season were calculated from kilometre to kilometre up to 30,000 m., giving the annual means p as shown in a table. The function $\log p$ is found to be sensibly linear in z. Its curve differs little from a straight line and shows a point of inflexion towards 14,000 m. Let us then write $\log p = l - mz + \phi(z)$. Substituting in the relation $dp = -a dz$, we get the following equation, h being a constant: $a/p = h(m - \phi')$. If $\log p$ were linear in z, a/p would be constant and T proportional to the product $g\ (1 - 0{\cdot}377e)$, subject to slight variations of temperature under the influence of meteorological phenomena. The slight sinuosities of the curve $(\log p, z)$ are sufficient to indicate the variations of a/p and of T; its point of inflexion is the graphic expression of the fact that, towards 14,000 m., a/p passes through a maximum, in correlation with the minimum of T at the entrance to the stratosphere. Instead of tracing the curve of the Δp in order to deduce therefrom the law of variation of the density a, it was considered preferable to seek for an expression of the function $\phi(z)$, and the following formula was established: $\log p = 2{\cdot}7955 - 0{\cdot}0622Z + (0{\cdot}3112Z + 15{\cdot}783)/(Z^2 - 12{\cdot}69Z + 180{\cdot}3)$, with $Z = \frac{z}{1000}$. The greatest relative discrepancy between the experimental value of p and that given by the formula is respectively less than $\frac{1}{1000}$, $\frac{5}{1000}$, and $\frac{10}{1000}$ for the altitudes comprised between 1 km. and 12 km., 12 km. and 23 km., 23 km. and 29 km. From this formula it is deduced that a/p is proportional to

$$0{\cdot}2 + (Z^2 + 101{\cdot}4Z - 823{\cdot}9)/(Z^2 - 12{\cdot}69Z + 180{\cdot}3)^2.$$

The maximum of a/p occurs when $z = 14{,}300$ m. Further, a/p tends towards a limit, so that the rise in temperature which starts in the stratosphere passes through a maximum under the inverse influence of g. Assuming the formula to be sufficiently accurate beyond 30,000 m., this maximum would occur towards 60,000 m., beyond which altitude T would diminish proportionally to g. The general expression found for a/p shows that this quantity passes through a minimum for $z = 550$ m., which agrees fairly with the mean temperature curves traced by Teisserenc de Bort. Variations are thus found for λ and ν which differ from those indicated in the previous note [Abstract 435 (1923)].
E. F.

1062. *Circumstances Determining the Distribution of Temperature in the Upper Air under Conditions of High and Low Barometric Pressure.*

A. H. R. Goldie. (Roy. Meteorolog. Soc., J. 49. pp. 6–16; Disc., 16–20, Jan., 1923.)—A series of 165 upper-air observations are considered in detail in order to investigate the relation between temperature and pressure at different heights; these are divided into two main groups relating to ascents in polar and equatorial air respectively. For each type the correlation between temperature and pressure is determined for each of the four months considered, and for the two regions 950–750 mb. and 700–500 mb. The coefficients are slightly higher than those given by Dines for temperature and pressure at the same level, and usually the correlation is higher in equatorial than in polar air. The correlation in equatorial air is higher in the region from 700–500 mb. than that in the region 950–750 mb., but in polar air there is little difference. A study of these observations, combined with the trajectories of the air currents involved, leads to the conclusions that for these latitudes: (*a*) In high pressure regions we should either have all polar air, or a surface layer of polar air and equatorial air above with a high stratosphere. (*b*) In low pressure regions we should have, either, all polar air with a low stratosphere, equatorial air which has been let down by retreating polar air, or a mixture of polar and equatorial air. Thus the variations with height of the correlation between pressure and temperature, and the greater height of the stratosphere over high than over low pressure, can be largely due to horizontal movements of air, and vertical motion on a large scale is unnecessary. A. W. L.

1063. *Radiotelegraphic Atmospherics in Relation to Meteorology.* **C. J. P. Cave** and **R. A. W. Watt.** (Roy. Meteorolog. Soc., J. 49. pp. 35–39; Disc., 40–42, Jan., 1923.)—It was shown in 1898 by Boggio Lera that the approach of a thunderstorm is indicated by atmospherics several hours before the arrival of the more familiar conditions. Later observations have shown that atmospherics are most severe in periods of low barometer, high wind velocity, rapid changes of temperature or pressure, and heavy rainfall. Between 1916 and 1920 observations of the intensity and direction of arrival of atmospherics were made by twelve Admiralty stations. These were used for locating thunderstorms, and in many cases storms thus located were recognised in subsequent meteorological reports. The distance of the storms from the observing stations varied between 5 and 1000 miles. The travel of the storm could be followed with the direction finder, a marked example being a storm near Aldershot on September 5, 1918, for which the results obtained agreed with the observed travel of the storm. A. W. L.

1064. *On the Radiogoniometry of Atmospherics and the Forecasting Weather.* **E. Rothé.** (Onde Élec. 2. pp. 7–18, Jan., 1923.)—Previous work by Popoff in 1895 and 1896, and later work by Turpain on atmospheric electricity is mentioned. The present writer employs Duddell's thermo-galvanometer for purposes of measurement. The various types of atmospherics are described, such as clicks, hums, sizzles, and grinders; the latter must be attributed to storms. The author made experiments on Eiffel Tower signals at Nancy in 1911 regarding the propagation of signals, and came to the conclusion that atmospherics were due to both local and distant storms. During the war he employed the radiogoniometer with valve apparatus to determine the route followed by storms, but circumstances did not permit a systematic study. In 1920, apparatus to determine the route of storms was installed at Strasbourg, and to measure wave-lengths by means of a goniometer having four large frame aerials and a commutator arrangement (illustrated). As a result it was possible to follow the course of a storm distant on the horizon, either by simultaneous observations of intensity of signals and visual observation by a second observer, or by graphic records. It was observed that, in the case of distant storms, there were privileged directions for the atmospherics, and maxima and mimima frequency could be found. The frequency of the atmospherics was found to be subjected to a diurnal variation, and it appeared one was able to correlate the frequency of parasites in a given direction with the frequency of depressions.

With short wave-lengths it was found that the atmospherics varied little as regards the natural frequency of the goniometer, but considerable variation occurred in this respect with wave-lengths of 25,000 metres. It would appear that the wave-lengths of atmospherics vary with their mode of production, but definite laws cannot be at present laid down. The paper gives various data and graphic records. B. J. L.

1065. *Earth Stratification.* **V. M. Goldschmidt.** (Zeits. Elektrochem. 28. pp. 411–421, Oct. 1, 1922. Paper read before Deut. Bunsen. Gesell., Leipzig, Sept., 1922.)—Physical-chemical considerations lead to the idea that the earth has been divided into four well-marked zones under the influence of gravitation. These are, from within outwards: A core of heavy metals, chiefly nickel-iron; a shell consisting of metallic oxides and sulphides; a shell of dense silicates, called eclogite shell; and a thin outer shell of the lighter silicates. The paper further contains a view of the processes of rock change in the outer portions, and some remarks on the cycles through which different chemical materials appear to pass during such changes. W. A. R.

1066. *Meteorite in Kentucky.* **G. P. Merrill.** (Am. J. Sci. 5. pp. 63–64, Jan., 1923.)—Pieces of meteoritic iron, weighing about 45 lbs., were found near Glasgow, in Barren County. It is a coarse octahedrite, but much oxidised. The analysis given shows a high content of chlorine. W. A. R.

1067. *Meteorite in Pennsylvania.* **G. P. Merrill.** (Am. J. Sci. 5. pp. 175–176, Feb., 1923.)—A nickel-iron meteorite, weighing 40 lbs. and having a coarse octahedral structure, was picked up on the Allegheny Mountain, Somerset Co. An analysis is given. W. A. R.

1068. *Photography of Meteors.* **F. A. Lindemann and G. M. B. Dobson.** (Roy. Astron. Soc., M.N. 83. pp. 163–166, Jan., 1923.)—Apparatus is described which has been used to photograph meteors in order to ascertain their height and velocity, and the most suitable plates, methods of development, and degree of fogging by stray light, for this purpose are considered. To obtain the speed of the meteor, a revolving sector is fixed over the lens of one camera. This sector is driven at constant speed electrically, and by this means the track of a meteor is seen as broken at regular intervals, giving the velocity. Photographs taken by the two cameras are given of a bright meteor whose height overhead was 83½ km., and velocity 35½ km./sec. The object is to obtain the temperature and density of the air at great heights. A. S. D. M.

1069. *Theory of Meteors and Density and Temperature of the Outer Atmosphere to which it Leads.* **F. A. Lindemann and G. M. B. Dobson.** (Roy. Soc., Proc. 102. pp. 411–437, Jan. 1, 1923.)—The paper relates to small meteors, *i.e.* of magnitude less than Venus, and defines them as extra-terrestrial particles, which enter the air at high speed; which become visible (owing to collision of the fast vapour molecules with air molecules) when their surfaces become hot enough to evaporate appreciably; and which disappear completely when they have evaporated almost wholly. Deceleration is small, and radiation from the particles is negligible. Liquefaction of the original cosmic particle and consequent spray formed by air pressure cannot occur at great heights except for very fast meteors, and need not be taken into account except when there are luminous trails. The authors develop the formulæ for head-resistance of the particle and for its surface temperature. Most of the energy of the particle is transformed into radiation, and therefore its mass can be found if its velocity is known. For an average meteor, traversing a path of $6\cdot10^6$ cm. in 1·5 seconds, appearing at a distance of $1\cdot5\cdot10^7$ cm., as bright as a first magnitude star, would have mass, $6\cdot25\cdot10^{-3}$ grm., and have (if of iron) a diameter of 0·115 cm. Meteors appear comparatively suddenly as they pass through a large mass of air before becoming luminous, since it is only when evaporation is great and the cloud of vapour is brought to rest by the air, that the luminosity becomes large and the meteor is seen. The surface of small meteors can only begin to evaporate when the whole particle has reached a temperature near that of the surface. The authors give equations for the density of the air at the height of appearance and disappearance repectively; the first including the mass and specific heat of the meteor, and the second its density (of which the rate of evaporation is a measure), and these results are accordant. W. F. Denning has published several hundred observations, and these have been used to calculate the atmospheric density and temperature at heights between 30 and 150 km. A diagram shows the densities of the air as measured by "ballons sondés" up to 20 km., and, as calculated on the assumption that it is isothermal at 220° Abs., from 20 to 200 km. From 30 to 50 km. the densities agree with the extrapolation of the "ballons sondés" measures; between 50 and 60 km., there is a gap because very few meteors disappeared and none appeared between these heights; from 60 to 160 km. there are plenty of meteors, but all indicate densities much greater than a temperature of 220° Abs.—more like 300° Abs.—the difference of density at height 150 km. being of the order of 1000 times. The authors confirm their results by other evidence; give a probable explanation of the absence of meteors appearing or disappearing between 50 and 60 km.; and of the observed high temperature above 60 km. They suggest the application of the results to the theories of auroræ, and they pay a very high tribute to the accuracy of the eye observations of meteors, made by W. F. Denning and his fellow observers. A. S. D. M.

1070. *Epsilon Arietis Meteors.* **C. P. Olivier.** (Roy. Astron. Soc., M.N. 83. pp. 87–92, Dec., 1922.)—The author criticises the list of 25 Epsilon Arietid radiants deduced from observations made between 1921 July 10 and Dec. 31, by W. F. Denning, A. G. Cook, and J. P. M. Prentice on three grounds: (1) That the hour angle of the radiant is omitted from the data given; (2) that the practical and theoretical reasons against the existence of such a fixed radiant seem almost insuperable; (3) that though the records of the American Meteor Society include tables of over 1200 radiants, based on about 31,000 meteors observed during 20 years, yet only six other radiants are found within 5° of the assumed fixed point, and but one of these falls within the extreme limits of the positions given in the paper under discussion. The A.M.S. had no particular expectation of finding a radiant near Epsilon Arietis, and therefore kept no special watch on it; but "on the contrary there could have been no possible bias"; therefore as regards the three observers, "before their conclusions can be unreservedly accepted, this radiant should be independently investigated and proved to exist by other observers." A. S. D. M.

1071. *Photograph of a Bright Meteor.* **W. J. S. Lockyer.** (Roy. Astron. Soc., M.N. 83. pp. 92–93, Dec., 1922.)—Description and reproduction of fireball from the radiant Kappa Tauri impressed on a fixed plate exposed from 8 h. 58 m. to 11 h. 12 m., G.M.T., on Nov. 16, 1922. The intensity of illumination of the path of the meteor is very unequal, but as it is much brighter than the slowly moving Polaris (2·62 photographic magnitude), and its own exposure can only have been a small fraction of a second, its brilliancy must have been very great. A. S. D. M.

1072. *Estimation of the Continuous Spectrum of Stars.* **R. A. Sampson.** (Roy. Astron. Soc., M.N. 83. pp. 174–204, Jan., 1923.)—A preliminary account of an investigation at the Royal Observatory, Edinburgh, on the use of the photoelectric cell in astronomy, and an attempt at a determination of stellar temperatures by this means. The principle and construction of the cell is described; its adaptation as an equivalent to Koch's photometer: the telescope and prism by which the spectra are obtained; and the plan of observation. To insure that the measures should be significant of stellar circumstance only, at least one trail of Polaris is taken on each plate, and the measures of other stars recorded on the same plate are made relative to this. The author explains the theory by which the comparison is made; he derives an equation for the comparison of photograms of two different stars in order to deduce information as to their relative temperature; and adopting for Capella the value 5500°, he gives resultant temperatures for 16 other stars, varying from 16,900° for γ Cas to 3500° for β And. A. S. D. M.

1073. *K-Term in B-Type Stars.* **S. Albrecht.** (Astrophys. J. 57. pp. 57–62, Jan., 1923.)—The systematic errors, now commonly known as the K-term, have been shown to be due partly to inaccuracies in the laboratory values of wave-lengths [see Abstract 125 (1923)], such as those of oxygen and nitrogen. The author points out that the laboratory results for silicon are not at all satisfactory, differing widely from each other. If the systematic differences of laboratory stars are taken, the algebraic difference between the results of Frost and Brown and of Crookes amounts to 0·153 Å. or 10 km. per sec. in radial velocity. Blends of unequal components are subject to apparent shifts depending on the quality of the spectrograms, but possible differences in the relative intensities of the components from star to star or type to type would produce apparent shifts of the blends and introduce systematic errors in the radial velocities. As the physical conditions in the stars and in the laboratory spark are dissimilar, the laboratory conditions should be varied as much as possible.

The reality of the K-term is inseparably connected with the problem of determining fundamental radial velocities. A. S. D. M.

1074. *Lines of Unknown Origin in Various Celestial Spectra.* **F. E. Baxandall.** (Roy. Astron. Soc., M.N. 83. pp. 166–174, Jan., 1923.)—The list published in 1910 is amended by the exclusion of lines since identified, and the inclusion of others for which terrestrial analogues have been found. Especially all bright lines of Omicron Ceti, are included since the author considers the identifications of some of them with low-temperature lines of such elements as Fe, Mg, Si, very doubtful.
A. S. D. M.

1075. *Bright Lines in the Spectrum of o Ceti.* **F. E. Baxandall.** (Observatory, 46. pp. 82–85, March, 1923.)—An analysis of the available evidence for the metallic origin of the bright lines in *o* Ceti (Md type). A table is given of all the bright *o* Ceti lines recorded either by Stebbins or by Adams and Joy, and in it eight lines have been identified with Fe lines, one (or possibly two) with Mg, one with Si, and eight are unidentified. Except 4233 (an enhanced line), all the Fe lines belong to the two lowest temperature classes. The author gives reasons for not accepting unreservedly the identifications of the *o* Ceti lines with low temperature metallic lines, since about half the bright *o* Ceti lines, other than hydrogen, are still unidentified, and the other identifications may be due to fortuitous agreements in wave-length between stellar and laboratory lines. He urges the search for a weak, bright companion to bright Hδ on the less refrangible side and about 1·4 tenth-metres away from it; for, if present, it would be strong evidence that these bright *o* Ceti lines are identical with low temperature lines of non-gaseous elements. On the whole, however, the available evidence is conflicting. [See preceding Abstract.] A. S. D. M.

1076. *Absorption of Radiation Inside a Star.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 83. pp. 32–46, Nov., 1922.)—The author had calculated the stellar coefficient of absorption $k = 20$ to 40 c.g.s. units, and found it vary little from star to star, at least for giants. In the present paper, he leads up to the conclusion that when an electron encounters an ionised atom it will be captured if, and only if, it actually hits the nucleus of the atom. He works out the connection of k with the conditions of electronic capture, first numerically and then symbolically. He takes a giant star of mass 1·5 and type G and assumes for it $k = 23$, and molecular weight $m = 2\cdot83$, and finds that the number of quanta absorbed per gm. per sec. is $2\cdot40\cdot10^{33}$ and this equals the number of separate electron "lives" or number of free electrons multiplied by the "lives" per sec. enjoyed by each electron; each free electron has an average number of lives of $1\cdot20\cdot10^{10}$ per sec., and its average speed is $1\cdot47\cdot10^{9}$ cm. per sec., and its mean path during one life is 0·122 cm. The "free path" of an atom is that described until an encounter with an atom occurs of such a character as to lead to capture, during which path, however, a large number of encounters may happen which do not so result, and the author calculates that the radius of the region—the target—within which the electron must come to be captured, as $\sigma = 5\cdot98\cdot10^{-11}$ cm., so that it is smaller than the atom which has a radius of the order 10^{-8} cm. Owing to the positive charge of the nucleus electrons hitting the target will be drawn in close to it, so that d the radius of the true target is $5 \cdot 9 \cdot 10^{-13}$ cm., or about $0 \cdot 01\sigma$, and so is of the same order as the average radius of an atomic nucleus, and the conclusion follows that the nucleus constitutes the target. The author obtains the symbolic expression of d, which is practically independent of any assumption as to the chemical constitution of the star, but is more sensitive to change in m the degree of ionisation, which perhaps should be increased from 2·83 to 4·0, thereby increasing k in the ratio 1·84, and d in ratio 4·4. The author replaces k by ηk which is practically constant. He considers the cases of change of mass with velocity and of possible radiation of an accelerated atom; the first appears admissible, the second inadmissible astronomically.

A. S. D. M.

1077. *Applications of the Theory of Stellar Absorption-Coefficient.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 83. pp. 98–109, Dec., 1922.) In an earlier paper, k, the stellar absorption coefficient, was taken as constant; now $mkT^{\frac{7}{2}}/\rho$ = const., and the present paper deals with the astronomical consequences of this change, especially in the case of dwarf stars [see preceding Abstract]. The author obtains an equation determining the distribution of density in a dwarf star; when a solution of this is obtained for a particular star, if all masses be multiplied by M and all lengths by $M^{\frac{1}{3}}$ the densities are unaltered, and the equation will be satisfied if k is multiplied by $M^{\frac{2}{3}}$. In this way the mass can be varied at will. A table gives a solution for dwarf stars for values of the mean density, k being taken as $\frac{1}{8}G = 2 \cdot 22 \cdot 10^{-8}$. A second table gives for the sun (mean density, 1·378) values of m (molecular weight), ρ_0 (limiting density under infinite pressure), ρ_c (central density), and temperature in millions of degrees. Here the range of values within which ρ_0 may lie, say, from 7 to 16 gm. per sec., corresponds to the range of m from 3 to 4, which are also the most probable values, and affords an indication that the theory, first developed for giant stars, works satisfactorily for the sun. The central temperature for the sun is higher than for a giant star at the corresponding stage, since in high temperature, strong ionisation and low molecular weight is to be expected, though the high density inhibits ionisation to some extent. Therefore $m = 3 \cdot 21$, $\rho_0 = 12 \cdot 8$, and central temperature = 18·4 million degrees, are taken as nearest the actual conditions. For Sirius ($\rho_m = 0 \cdot 455$) with $\rho_0 = 12 \cdot 8$, $m = 2 \cdot 55$, and there is a loss of 20 electrons instead of 16 for the sun, for atomic weight 54. The effective temperature varies practically as the square of the molecular weight, and since stars a little less massive than $\frac{1}{8}\odot$ seem able to reach about 3000°, we should expect the maximum effective temperature for such a star to be about 3500°; this would be obtained by increasing the molecular weight from 4 to 5·4, with a central temperature of 12 million degrees and loss of 9 electrons. The author finds that a star of the sun's mass does not rise above 6600° (instead of 9000° as given formerly), and Sirius (judging from its mean density 0·45) like the sun, is not far from its highest temperature, so that we may infer 11,000° as the maximum for mass 2·4. (Probably 2·5 is the typical mass for giant stars.) A further table gives the absolute bolometric magnitudes of giant stars.

A. S. D. M.

1078. *Collective and Discontinuous Evolution of Stars and Nebulæ.* **E. Belot.** (Comptes Rendus, 176. pp. 567–570, Feb. 26, 1923.)—The author states that evolution in general is discontinuous with variable mass (cellular division, radiation by quanta, etc.), and collective, depending on the surrounding medium and on the number of individuals evolving in a given space. He criticises Russell's giant and dwarf theory as not corresponding with cosmical reality in that it assumes constant mass for stars, and as inconsistent with the diameter of the proto-sun given by the dualistic cosmogonic theory; and he proposes instead a comprehensive theory embracing both stars and nebulæ. Kapteyn's two-drift theory leads to the origin of the universe from two cold nebulæ, one in slow rotation and the other coming from the direction of Sagittarius. From the collision between these the author draws three general conclusions: (1) The evolution of stars cannot be separated from that of the hot or cold nebulæ; (2) contrary to Russell's theory that a star has constant mass and can at most pass only twice through each spectral type, any star has variable mass and may pass many times through each type. Cepheids and B-type stars lie near the Milky Way, dwarfs like the sun in mass and volume at a distance from it. (3) Hot and luminous nebulæ owe their radiation and movements to stellar collisions; they are less massive than cold nebulæ and are most numerous near the plane of the Milky Way. A. S. D. M.

1079. *Star of Greatest Known Mass.* **J. S. Plaskett.** (Roy. Astron. Soc., Canada, J. 16. pp. 284–293, Nov., 1922.)—The author had on his observing list B.D. 6°·1309 [R.A. 6 h. 32.0 m., Dec. + 6° 13′ (1900)], visual magnitude 6·06, classified as A5 in Harvard **50** but as Bop in the Henry Draper Catalogue. The first spectrum obtained on 1921 showed doubled spectrum lines of type about O*e*5. The velocity range was unusually large and 30 spectra were obtained by April 5, 1922. Were it not for the doubled lines and large displacement, there was nothing to mark it out as extraordinary. The component spectra are similar, but the fainter is weak and diffuse. Its period is 14·414 ± 0·016 days, and the minimum values for the masses are 75·6 ⊙ and 63·3 ⊙, that for the system being 138·9 ⊙. The mass is certainly greater than this, for if the plane of revolution were nearly in the line of sight it would be an eclipsing variable, and such has not been observed though it is a naked-eye star. The total mass is probably 160 ⊙, and may be 230 ⊙, but the minimum masses are those used. The absolute visual magnitudes are deduced to be − 5·65 and − 5·4, and the total magnitude for the system as − 6·3. The probable temperature is 17,000 K (of the same order as Rigel in brightness and mass), the density may be taken as 0·01. The brighter component will be therefore nearly 20 times the sun's diameter. Its distance is about 3000 parsecs. As in other high-temperature stars, the H- and K-lines are abnormal, sharp and strong, and have a nearly stationary velocity of + 16·0 ± 0·25 km., as compared with 6° 1309 of + 23·9 ± 1·4 km., the system receding from the sun 8 km. per second faster than the cloud. The author rules out the displacement of lines to the red in the spectrum of heavy bodies, since a relativity shift of 8 km. would require the inadmissible density of 0·4 for this very hot star. He rules out also an enveloping cloud and considers that there is an intervening calcium cloud, stationary with respect to the system of the stars from which the solar motion is determined. A. S. D. M.

1080. *Orbit of Comet* 1911 *b* (*Kiess*). **E. Hahr.** (Astron. Iakttagelser och Undersökningar Stockholm, 10. 10. [27 pp.] 1921.)—Comet

1911 b was observed for only 70 days (July 7th to September 18th), appearing as a diffuse nebula of large diameter and vague central condensation. The first set of elements were found to have large residuals, and the author reduced these considerably, but not wholly, by assuming that there was an issue from the inner part of the comet, so that the centre of the observed part was not coincident with the centre of gravity, and by correcting the elements for a variable angular distance between these two. He makes the further suggestion that the central condensation may have been rotating about the centre of gravity. A. S. D. M.

1081. *W. Struve* (Σ) *Double Stars.* **J. Jackson.** (Roy. Astron. Soc., M.N. 83. pp. 4–32, Nov., 1922.)—Ninety years have elapsed since Struve's first systematic survey for double stars, and most systems that are merely optical should have been shown up. Only about 650 of the 3112 Σ doubles have exhibited appreciable relative motion, but the physical connection is also proved if they have common proper motion. For 2659 doubles, the author classifies them as pairs showing (A) relative motion and (B) not *certain* relative motion. The A class he again divides into (1) binary systems, (2) optical systems, (3) nature uncertain. He discusses 127 stars from (1) which have not been included in the paper on "Hypothetical Parallaxes of 556 Visual Double Stars" (M.N. 81, 2) and of (3) he concludes that of the 39 stars considered only 12 are possibly binary; for these he deduces parallaxes ranging from 0″·043 to 0″·085. He finds that the proportion of double stars and of binaries is rather greater amongst dwarfs than giants; by arranging the binaries according to hypothetical parallax and spectral type, it appears that there is a real scarcity of early type stars in space, and it is their brilliancy which enables them to be seen at great distances, and so come into catalogues. It is of importance to know what number of optical pairs should be allowed for chance inclusions, and the author concludes that all opticals with separation under 16″ have been already found. A. S. D. M.

1082. *Investigations on Proper Motion. Ninth Paper. Internal Motion in the Spiral Nebula Messier* 63, *N.G.C.* 5055. **A. van Maanen.** (Mt. Wilson Observat. Contrib. No. 255. Astrophys. J. 57. pp. 49–56, Jan., 1923.)

1083. *The Radial Velocities of* 1013 *Stars.* **W. S. Adams** and **A. H. Joy.** (Mt. Wilson, Observat. Contrib. No. 258. Astrophys. J. 57. pp. 149–176, April, 1923.)—These stars, almost wholly of spectral type F to M, have been observed with a one-prism spectrograph on the 60-inch and 100-inch reflectors at Mt. Wilson. AUTHORS.

1084. *Galactic Longitudes of Spiral Nebulæ.* **J. H. Reynolds.** (Roy. Astron. Soc., M.N. 83. pp. 147–152, Jan., 1923.)—All known globular clusters and spiral nebulæ (down to 2′ diameter) are plotted on three polar graphs for each galactic hemisphere [see M.N., 81, Plate 4], but as the longitudes 50°, 140°, 230°, and 320° prove to be of fundamental importance, the longitude 50° to 230° are taken as horizontal, and the longitudes of apex and antapex vertical. In all three graphs, all globular clusters are plotted, but for the spirals, the graphs are divided into those for diameter of 10′ and upwards; for 5′ and under 10′; and for 2′ to 5′.

For the large spirals in both galactic hemispheres, longitude 100° forms a well-marked band ; and for these objects, galactic longitude is of primary importance, latitude being secondary. In each hemisphere the nebulæ approach quite close to the galaxy about this longitude (100°). Of the spirals of large angular diameter there is a concentration in the southern galactic hemisphere, though the majority of the class of over 10′ are in the northern. In the second graphs, the longitude 100° is also marked, and in the north there is an extension from it beyond the pole along 280°. In both hemispheres, there is great scarcity of spirals in the quadrant 320° to 50° (through 360°). In the third set of graphs, the spirals of small apparent dimensions are widespread and in both hemispheres extend into the barren regions (50° to 230° through 360°), but there are two principal concentrations in the north, each extending 10 square degrees, and lying on each side of the north galactic pole. Broadly speaking, spirals and globular clusters are mutually exclusive, especially in the north where the globulars are all in the semi-hemisphere 50° to 230° through 360°. As the angular diameter of the spirals decreases, their inclination to the line of sight tends to 30°. A correlation is suggested between diameters, magnitudes, and distances of spirals, as Shapley has shown holds good for globulars ; there is definite evidence of a band widespread in Ursa Major, stretching past the pole beyond Virgo, and becoming smaller in average size in so doing. No suggestion is offered to account for the scarcity of spirals in the quarter 320° to 50° (through 360°). This same region contains 50 globular clusters out of a total of 81. A. S. D. M.

1085. *Lundmark's and Lutyen's Papers on Determination of Colour-Equivalent of a Star.* **B. Lindblad.** (Roy. Astron. Soc., M.N. 83. pp. 97–98, Dec., 1922.)—The author emphasises the following points : (1) That a considerable part of the dispersion of $\lambda_{\text{eff.}}$ for the late spectral classes in Davidson and Martin's results at Greenwich may be accounted for by errors of measurement and spectral classification in addition to the effect of varying luminosity within the types ; (2) that the discussion of the combination of $\lambda_{\text{eff.}}$ and $\lambda_{\text{min.}}$ is misleading. The qualitative difference between the two colour-equivalents is quite evident, and is not due to a higher accuracy in the measurement of $\lambda_{\text{eff.}}$; $\lambda_{\text{min.}}$ is, obviously, relatively more sensitive to a change in luminosity within the same spectral type than $\lambda_{\text{eff.}}$. It is clear that this first can be used to discriminate to some extent between giants and dwarfs, as stars of different luminosities will show different characteristic combinations of $\lambda_{\text{eff.}}$ and $\lambda_{\text{min.}}$; (3) that $\lambda_{\text{eff.}} - \lambda_{\text{min.}}$ depends qualitatively on the strong cyanogen band at λ3883 Å., which is stronger in absorption for giants than dwarfs in G5 – K5 ; (4) that the general colour effect of absolute magnitude may be simply a change of effective temperature. [See Abstracts 451 (1923) and 1107 (1922).] A. S. D. M.

1086. *Film Distortion and Stellar Images.* **F. E. Ross.** (Eastman Kodak Co., Research Lab. Comm. No. 154. Astrophys. J. 57. pp. 33–48, Jan., 1923.)—Photographs of artificial stars are taken on plates 1 inch wide and careful measurements made. No systematic error is found for images outside each other's influence. Local variations in the emulsion produce small effects. Astronomical plates with thin emulsions suffer less from film distortion than those more heavily coated. Intensification does not move the "centre of gravity" of an image. On drying there is no lateral shift of the images except near the edges of the plate. In a long series of measurements the mean distortion is 0·0005 mm. and the maximum 0·002 mm. A. Wh.

1087. *Disturbed Motion about the Equilateral Triangle Equilibrium Point.* **W. M. H. Greaves.** (Roy. Astron. Soc., M.N. 83. pp. 71–79, Nov., 1922.)—The writer discusses the case of the Sun, Jupiter, Saturn, and a Trojan planet, and finds, so far as his work goes, that the disturbing influence of Saturn will not cause an asteroid situated near the equilateral triangle point B, corresponding to the Sun and Jupiter, to depart from the neighbourhood. His theory is similar to Goldsbrough's theory of the division in Saturn's Rings, but in both cases the equations of motion are themselves first approximations, and the inclusion of second order terms might reveal instability. The author proposes a method of further investigation which may shed light also on Goldsbrough's theory.

A. S. D. M.

1088. *Equilibrium of a Rotating Star.* **E. A. Milne.** (Roy. Astron. Soc., M.N. 83. pp. 118–147, Jan., 1923.)—Eddington's theory of the interior of a star at rest and consisting of a perfect gas [see Abstracts 893 and 1110 (1917)] of constant mean molecular weight, is extended to the case of a star in rotation. In a spinning star, the equatorial parts will tend to lift under centrifugal force, and for given rate of evolution of energy per unit mass, and for a given mass, the star's luminosity is smaller, and the polar parts hotter than the equatorial. The star suffers expansion which is superimposed on the ellipticity. The ellipticity is independent of the mass, but the expansion increases with the mass, and for large masses a comparatively small rotation has a large effect and the rotation shows a definite effect due to mass, perhaps to render it increasingly unstable; for large masses the character of the deviation from the non-rotating case is entirely different. If two stars with the same central temperature and the same rate of generation of energy are compared, the rotating star will have the larger mass. For a non-rotating star, the total radiation remains constant, but for a rotating star, it decreases steadily as the star contracts. Application is made to the case of Eddington's typical giant star of density 0·002, for which the author finds that the biggest permissible period of rotation is 6·2 days. The star has a radius of 7×10^6 km., an effective temperature of 6500° (type F7), a mean molecular weight of 2·8, and mass 1·5 the sun's. Its total luminosity is 2·5 per cent. less for an assumed rotation of 7 days; there is an expansion of the boundary as a whole of 6·1 per cent. of the radius, and superimposed on this is a polar contraction of 6·6 per cent., the equatorial axis being 10 per cent. longer than the polar. There is a reduction of 3·7 in the effective temperature, and the ratio of centrifugal force to gravity is 0·19. In rotating masses large as compared with the sun, where gas pressure is negligible as compared with radiation pressure, the material must arrange itself so that the specific volume is a certain linear function of the rate of energy of evolution per unit mass. In a sufficiently massive rotating star (with Eddington's assumptions), the density is constant through the material and so cannot be distinguished from a liquid, and the boundary conditions being the same it must take up one of the forms of a rotating gravitating liquid. The author deduces that in very large rotating masses, fissional break-up should always precede equatorial break-up; in this case the mass by repeated fission should lead to a number of bodies of comparable masses. The diminution in luminosity by rotation is much greater when the mass is large than when it is small. A. S. D. M.

1089. *Progression of Stellar Velocity with Absolute Magnitude.* **A. S. Eddington** and **A. V. Douglas.** (Roy. Astron. Soc., M.N. 83. pp. 112–118, Jan., 1923.)—Since intrinsically faint stars move faster on the average than bright ones, it is important to determine the amount of change of velocity per magnitude, and the considerable number of spectroscopic parallaxes now available provide material. But when used in conjunction with proper motions, the direct method may give fallacious results. The spectroscopic parallaxes are used to get absolute magnitudes and also to convert angular proper motions into km. per sec., but if by accident too bright an absolute magnitude is assigned, the star is located too far away and the deduced linear speed is too great. There is thus a tendency to attribute high velocities to (supposed) bright stars and low to faint stars. The purpose of this paper is to eliminate the effect of accidental error in the spectroscopic absolute magnitudes and to apply the theory to giants of type K. The number of stars investigated is 287, of types from G8 to K2 brighter than absolute magnitude 3·5 (the dividing line between giants and dwarfs), and arranged in order of absolute magnitude, in approximately five equal groups. In each group, rejecting the three highest velocities, the authors find that the progression of velocity with magnitude is more than doubled on the assumption that the probable errors of magnitude determination is ± 0·4 m. instead of ± 0·3 m. Unfortunately, there does not seem a prospect of determining this probable error with greater precision, and an increase in the number of stars observed will not diminish the difficulty. A. S. D. M.

1090. *On the Regularity of the Axial Rotation of Planets.* **A. Klose** and **H. Kaul.** (Phys. Zeits. 24. pp. 66–67, Feb. 1, 1923.)—This note is a critical comment by Klose on a previous paper by Kaul [see Phys. Zeits. 23. p. 184 (1922)] and is followed by a short reply from the latter. Klose considers the publication to be a numerical fallacy, a conclusion which is repudiated by Kaul, who refers his opponent to a later communication by him [Astron. Nachr. No. 5199, Dec. 2, 1922]. H. H. Ho.

1091. *Speed Obtained in Equatorial Measures of Minor Planets with the Photo-Visual Comparator.* **J. P. Lagrula.** (Comptes Rendus, 176. pp. 669–671, March 5, 1923.)—In 1913, a description was given of the photo-visual comparator [see Abstract 1604 (1913)]. In 1922, by its means, 25 minor planets were picked up without previous knowledge of their positions. In the present paper, the author describes the Right Ascension reticule which can be so quickly installed or removed at pleasure, that the observer, in fact, proceeds by a single series of operations as in a transit instrument. When minor planets have been already discovered, it is possible to get their positions again in a time so short, that it is negligible as compared with that needed for ordinary differential measures; and the author gives an extract from his observing-note-book, of the magnitudes and times of observation of 27 minor planets, picked up and measured between 8 h. 4 m. and 13 h. 11 m. G.M.T. on December 25, 1922. A. S. D. M.

1092. *Babylonian Origin of Chinese Astronomy.* **L. de Saussure.** (Arch. des Sciences, 5. pp. 5–18, Jan.–Feb., 1923.)

1093. *Simple Expression for the Acceleration of Mercury in the Case of the Problem of Two Bodies.* **E. Pasquier.** (Comptes Rendus, 176. pp. 498–500, Feb. 19, 1923.)—The author finds for the acceleration with respect to the stars $J = fM/r + 2d\omega/dt\sqrt{fM(2/r^2 - 1/a)}$, where $d\omega/dt$ is the movement of the perihelion of mercury, f is Gauss's constant, M the sun's mass, and a the semi-major axis of the orbit; suitable units and a moving system of axes in the plane of the planet's orbit and perpendicular to that plane, being taken. A. S. D. M.

1094. *18-Inch Refracting Telescope for the Brazilian Government.* (Engineering, 115. pp. 130–131, Feb. 2; 161–162, Feb. 9, and pp. 223–225, Feb. 23, 1923.)—Particulars of the equatorially mounted achromatic refractor of 18 inches clear aperture and 21 ft. 4 in. focal length, erected at the Observatorio Nacional, Rio de Janeiro, by Messrs. Cooke, Troughton, and Simms, Ltd., are given in detail. The features which distinguish this design are: (1) The fitting of ball bearings to the polar axis of the equatorial mounting, as first used by Messrs. Cooke, greatly reduces the strain and wear on the driving gear. (2) The lines corresponding with the number and position of the teeth on the driving wheel were cut on a large automatic dividing engine of extreme accuracy. The cutting of the final divisions on the periphery of its main wheel or table (from which its 720 ft. were afterwards cut), involved over 50,000 micrometer settings. The resulting pitch error, measured singly or cumulatively, in the divisions so corrected, amounted to no more than half a second of arc, or a lineal error of only 1/20,000th of an inch. After the cutting of these lines, each division of the wheel in turn is set between the lines in the field of a microscope mounted on a special gear-cutting machine, and correspondingly accurate teeth cut in turn; the teeth are not afterwards touched with a tool; the most that is done is to run the wheel for a week or two in gear with its own driving worm of fine unhardened steel, and to use fine rouge to induce a smooth-running tooth surface where contact takes place. (3) The accessories for the eye-end of the telescope, such as the position micrometer, spectroscopes and camera, are all of the same weight, and thus, which ever is used, the balance of the telescope remains undisturbed. A. S. D. M.

LIGHT.

1095. *Report of the Committee on Nomenclature and Standards, 1922.* (Am. Illum. Eng. Soc., Trans. 18. pp. 47–54; Disc., 54–61, Jan., 1923.)—Draft definitions are given.

1096. *Optical Properties of some Metallic Sulphides.* **E. P. T. Tyndall.** (Phys. Rev. 21. pp. 162–180, Feb., 1923.)—Results are given, in the case of molybdenite and stibnite, for reflectivity, transmission indices of refraction and extinction. Reflectivity is also given for pyrite and galena. W. R. C.

1097. *Optical Constants of Isolated Tellurium Crystals.* **G. D. Van Dyke.** (Optical Soc. of America, J. and Rev. Sci. Inst. 6. pp. 917–921, Nov., 1922.)—The author uses Weld's "crystelliptometer" [Abstract 1268 (1922)] to determine the optical constants of a tellurium crystal by Drude's method. The crystals are made by sublimation and the optical constants for five different wave-lengths in the visible spectrum obtained. The results show that the crystal is doubly refracting, the index of refraction being higher when the principal crystal axis is parallel to the plane of incidence than when it is perpendicular. The reflecting power of the crystal varies very little for the two positions and the various wave-lengths. Plotting index of refraction against wave-length, the index shows a distinct minimum and maximum in the range investigated. This is similar to Skinner's results for selenium, but in the case of tellurium the two indices follow almost similar curves. T. H.

1098. *Measurement and Specification of Optical Characteristics in Projector Performance.* **G. W. Moffitt.** (Optical Soc. of America, J. and Rev. Sci. Inst. 6. pp. 940–948, Nov., 1922.)—There is an increasing demand for higher efficiency of projection lenses. With advances in projection lens design the need has arisen for a workable system of measurement and specification of lens performance and of the optical characteristics of projector performance in general. Lens bench tests are indispensable to the designer to determine in what way a lens is failing, but with such precision tests there is sometimes a tendency to judge too critically. These tests are made with uniform illumination over the aperture of the objective, whereas, actually, in projection, the intensity distribution over the area of the aperture is far from uniform, and this lack of uniformity is such that the performance of the lens is often better than a bench test would suggest. The lens should be tested in position and under actual working conditions. The author proposes the use of standardised stencil plates to be placed in the film-gate of the projector for testing a lens for its power of definition, illuminating power at the screen, and quality as determined by those characteristics which affect its ability to render faithfully the contrasts of the film, *e.g.* flare-spot and flare. A system of measurement and specification is outlined by the use of which the optics of projection may be placed on a definite basis. T. H.

1099. *Qualitative Study of Inflected Waves.* **R. N. Ghosh.** (Phil. Mag. 45. pp. 225–228, Jan., 1923.)—The author describes a simple optical experiment which qualitatively demonstrates the existence of inflected and cusped wave-fronts. Light is caused to diverge from a slit and fall upon a silvered cylinder of glass. A short focus microscope is used to view the rays grazing the edge of the cylinder and placed so that its focal plane is between the cylinder and the slit. The rays after deflection at the surface form a virtual caustic within the cylinder and the caustic becomes a virtual source of light. As the rays pass through the microscope objective they converge or diverge according as they lie away from or within the focal plane. After passage through the objective a part of the wave is converging while another is diverging, *i.e.* there is an inflected wave behind the objective. As the inflected wave travels on, the curvature of the diverging part goes on increasing while the other half comes to a focus and there diverges, folding upon the former half and giving rise to a cusped wave-front far behind the objective. This folding gives rise to interference phenomena of exactly the same type as obtained in the case of a wave emerging from a raindrop. The existence of the inflected wave-front can be observed by moving a thin vertical wire along the wave-front just behind the objective and observing the shadow in the region where the cusped wave-fronts are formed. As the wire moves across, the shadow first approaches the principal maximum and then retraces its path after reaching the place of maximum illumination, which lies in the direction of the cusp. The shadow moves along one part of the cusp and retraces its path along the second part of the cusped wave-front. The alteration of the interference pattern caused by the presence of the wire is observed and agrees qualitatively with the effect expected from calculation. T. H.

1100. *Temperature Coefficient of Refractive Index of American Turpentine.* **G. Thompson.** (Chem. News, 126. pp. 20–21, Jan. 12, 1923.)—It is impossible to compare refractive indices unless these refer to the same temperature; nevertheless few attempts have been made to measure and record the variation of refractive index with temperature, especially for commercial liquids. The only available information for American turpentine gives the temperature coefficient as 0·00037 decrease in refractive index per 1° C., which figure is so low as to be quite outside the usual range for essential oils. The author examines four samples of the best commercial varieties of American turpentine, using a Pulfrich refractometer and a sodium flame over a range of temperature from 14° C. to 60° C. The tabulated results show that there is little, if any, tendency for the temperature coefficient to alter with temperature. The means of the temperature coefficients for the four samples vary between 0·0004684 and 0·0004706 per 1° C. T. H.

1101. *Refraction in Cylinders and Spheres.* **J. Würschmidt.** (Phys. Zeits. 24. pp. 14–16, Jan. 1, 1923.)—The author points out that C. Schmidt's formula for finding the refractive index of a sphere [see Abstract 45 (1923)] is an approximation which becomes rigorous only when the source is situated at the centre of the sphere. J. W. T. W.

1102. *Reflection of Ultra-Violet Light by Flowers.* **F. K. Richtmyer.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 151–168, Feb., 1923.) —Has reference particularly to the part, if any, played by ultra-violet light in attracting insects to flowers. Results inconclusive. W. R. C.

1103. *Theory of Vision.* **F. Schanz.** (Zeits. f. Physik, 12. 1 and 2. pp. 28–37, 1922.)—The thermal effects of light on living tissues seem only to accelerate the chemical effects. Under the influence of light absorbed by it, the albumen of the crystalline lens tends to harden and become insoluble, as may be shown experimentally; and this is a property of albumens in general. Long waves act similarly when a sensitiser is added. Albumens give a good photoelectric effect, increased by sensitisers. In vision, light can only act where it is absorbed, namely, in the pigment layer of the retina; and there it liberates electrons. These electrons are caught by the rods and cones, which act like the gauze screen in photoelectric experiments. Each impinging wave-length produces its own electron-velocity; and in monochromatic light the sensation of colour is associated with the impact of electrons at a particular velocity and the production of a particular electric current. There appears to be no case in which even albinos are wanting in retinal pigment. There is a certain spatial distance between the pigment and the rods and cones. A sensation of white light is due to mixed electron velocities; and the production of a single colour sensation by mixed wave-lengths is due to an averaging of these velocities. When two wave-lengths differ by 200 $\mu\mu$, this averaging becomes impossible, and the resultant sensation is one of white (complementary colours). Rays of 500 to 560 $\mu\mu$ have ordinarily no complementary colour; but after treatment for cataract the spectrum is lengthened, the ultra-violet rays being no longer absorbed; and this new region of the spectrum is complementary to the wave-lengths from 500 to 560 $\mu\mu$. Various ocular phenomena are successfully coordinated by the new theory. A. D.

1104. *Study of Visual Processes by Means of Momentary Retinal Shadows.* **F. W. Ellis.** (Optical Soc. of America, J. and Rev. Sci. Inst. 6. pp. 922–931, Nov., 1922.)—The author calls attention to what appears to be a new method of studying several visual phenomena. When a slender horizontal rod is moved vertically in front of a rapidly revolving disc having a white or coloured sector of greater luminosity than that of the rest of the disc a number of horizontal bands is seen. The following explanation is given. As the white sector sweeps behind the rod, a variable portion of it is covered by the rod at successive instants and the retinal image or shadow of the rod is formed in successive sections. When the disc revolves rapidly the continuously varying parts of the shadow are perceived as a whole owing to persistence of vision. At each revolution of the disc the sector encounters the moving rod in another part of the field and consequently another shadow is formed. As the persistenee of vision is a considerable part of a second, several bands are seen at the same time, their number depending upon the rate of revolution of the disc and their distance apart upon the speed with which the rod is moved across it. The author describes some variations of the experiment, and uses one to measure the duration of visual perceptions. The rod is arranged to rotate (in a plane parallel to the disc) about one end kept on the axis of the disc. The bands are then radial and if the rate of revolution of the rod be adjusted they can be made to cover the entire disc. The time of revolution of the rod measures the duration of the perception, about 0·4 sec.

Visual inhibition is clearly demonstrated in the bands. With a white sector on a black ground the fusion colour is grey, but the bands are nearly or completely black. It is possible by altering the angle of the sector to reduce the duration of the retinal shadow to less than 0·001 sec., but the previous grey sensation is inhibited and a perception of a black band corresponding to the retinal shadow remains. Another condition, the refractory state, also plays a part in the production of the bands. The retina shadow lasts less than 0·001 sec., the perception 0·4 sec., and under appropriate conditions the perception may outlast the retinal shadow a thousand times. During the period 0·4 sec. the part of the retina upon which the shadow falls is stimulated at least twelve times by the repeated passages of the sector without evoking any sensation. The perception of the shadow made that part of the visual field refractory to stimulations by the light of the sector, indicating that in the processes of vision sensations which interfere with clearness of perception may be suppressed. Visual perceptions are due to the activity of the higher visual centres, and it is most probably in these centres that inhibition and the refractory state occur. T. H.

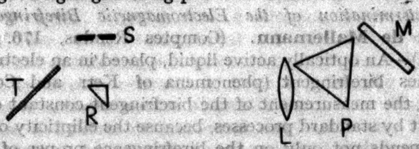
1105. *Transformation of Colour-Mixture Equations from One System to Another.* II. **H. E. Ives.** (Frank. Inst., J. 195. pp. 23–44, Jan., 1923.)—In a previous paper [see Abstract 178 (1916)] an outline was given of the processes necessary for transforming colour measurements from one trichromatic system to another, and from a trichromatic to the monochromatic system (spectral hue, luminosity, and purity). In the present paper the same problems are treated by graphical methods, with the limitation that the absolute luminosity, or the level in the space figure representing the colour system, is not considered. The graphical methods are illustrated by means of several typical examples. A. W.

1106. *Determination of the Electromagnetic Birefringence of Active Liquids.* **R. de Mallemann.** (Comptes Rendus, 176. pp. 380–382, Feb. 5, 1923.)—An optically active liquid, placed in an electric or magnetic field, becomes birefringent (phenomena of Kerr and Cotton-Mouton). Nevertheless, the measurement of the birefringent constant cannot usually be carried out by standard processes, because the ellipticity of the emergent vibration depends not only on the birefringence proper of the body but on its rotatory power also. To render the substance inactive by mixture of inverse forms is not always practicable, and the only attempts recorded in this direction, *viz.* for turpentine by Quincke and for certain amyl derivatives by Schmidt have been failures. These authors had not grasped the theoretical problem, *viz.* that directly observable birefringence must be distinguished from the true birefringence obtained by deduction from the elliptic effect proceeding from the rotatory power. This is briefly discussed by the author, who points out that considerable simplification results by using Poincaré's spherical representation, and formulæ are derived which have been applied to the case of electric birefringence whereby the Kerr constants have been determined for a series of active liquids of very different rotatory powers. In the majority of cases Gouy's relation has been approximately verified ($\delta^2 = \phi^2 + 4\omega^2$, where δ is the elliptic birefringence, ϕ the ordinary value, and ω the rotation), in certain cases exceptions appear to exist. H. H. Ho.

1107. *Telescopic and Entoptic Diffraction Rays.* **J. Larmor.** (Cambridge Phil. Soc., Proc. 21. pp. 410–413, Feb. 8, 1923.)—Gives the mathematical proof of statements made in abstract in a paper communicated to the Mathematical Congress at Strasbourg in September, 1920 (Report, p. 589). Each straight edge in the aperture gives rise to a ray of diffraction normal to that edge. If there are two parallel edges on the aperture the interferences along the ray of diffraction will produce alternations of bright and dark places in the case of homogeneous light. J. W. T. W.

1108. *A Registering Microphotometer.* **E. Pettit** and **S. B. Nicholson.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 187–193, Feb., 1923.)—Description of an instrument assembled at the Mount Wilson Observatory. The image of a brightly illuminated slit is focused on the photographic plate to be measured and an image of this illuminated strip thrown on to a vacuum thermo-couple by a microscope objective. Several times the usual length of slit can be utilised by putting two plane mirrors within the microscope tube with their planes at right angles to the slit. This allows a very narrow slit to be used without accentuating unevenness of grain. The plate is moved steadily across the stage of the microscope by a controlled motor drive; and through a suitable gear, giving ratios from 2 to 500, a photographic plate is moved across the scale of a reflecting galvanometer which is connected to the thermo couple. Examples are given showing the intensity distribution across the H and K lines of the solar spectrum and the head of the λ3890 carbon band. A. Wh.

1109. *Simple Prism Spectrograph.* **E. O. Hulburt.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 205–206, Feb., 1923.)—Describes a simple form of spectrograph designed to combine as high a dispersion as possible with good light-gathering power at small cost. The spectrograph is shown in the figure. The light from S is rendered parallel by L, dispersed at P, reflected by M, and brought to a focus at T. The photographic performance of the system is shown by sample spectrographs reproduced in the paper. The dispersion at 5000, 4000, and 3600 Å.U. is approximately 40, 20, and 15 Å.U. per mm., respectively. The total cost was about 30 dollars. J. W. T. W.



1110. *Abolition of Astigmatism of Oblique Bundles in Case of a Single Lens.* **J. P. C. Southall.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 219–220, March, 1923.)—Errata affecting nearly all the numerical results given in the paper referred to in Abstract 844 (1922). W. R. C.

1111. *Unit Surfaces of Cooke and Tessar Photographic Lenses.* **A[lice] Everett.** (Phys. Soc., Proc. 35. pp. 55–66, Feb., 1923.)—A number of rays in an axial plane (and a few general rays) are traced through the lens systems of two particular photographic lenses by exact methods, and on each ray the positions of the conjugate points for unit magnification are found by T. Smith's formulæ. The results show that for general rays the loci of these "unit points" are three-dimensional. The loci are surfaces only when the chief rays are bound by some condition, such as passing through a fixed point of the object. In this case the unit surfaces are not fixed, but shift with the object point. The curvature changes with aperture, and with the distance of the object point from the optic axis. Hence the unit surfaces cannot coincide with wave-fronts. Within the region for which the lenses are designed, the curvature of both object and image unit-point loci is positive (convex to the light source) and the image locus is more curved than the object locus. These facts do not coincide with the theoretical conclusions obtained by Smith for either a thin system or an ideal thick system, but accord more nearly with the latter, especially as regards the sign of the difference of curvatures of the two-unit surfaces.

If, instead of a pencil of rays from a given object point, rays are taken satisfying some other condition, such as passing through the vertex of the lens, or having a given aperture, *i.e.* having H, the perpendicular on the ray from the vertex given, then quite different forms are obtained for the unit surfaces. J. W. T. W.

1112. *Correlation of Elementary Proofs of the Fundamental Properties of Oblique Deviation by Prisms.* **H. S. Uhler.** (Optical Soc. of America, J. and Rev. Sci. Inst. 6. pp. 1072–1075, Dec., 1922.)—The object of this paper (which is unsuitable for detailed abstraction) is to indicate how the general properties of deviation produced by triangular prisms surrounded by a single medium may be deduced without making use of either spherical trigonometry or the calculus of infinitesimals. The advantage of this is to enable authors of elementary text-books to generalise, without difficulty, the usual discussions of prismatic refraction. T. H.

1113. *Practical Application of Parabolic Surfaces in Lens Construction.* **W. B. Rayton.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 197–202, Feb., 1923.)—It has been found possible to produce on a manufacturing scale lenses having a parabolic surface, with very great improvement in performance both as regards spherical aberration and astigmatism. The performance obtained in the case of $a + 12 \cdot 00$ D spectacle lens with front surface parabolic, and the improvement effected in a projection condenser by the introduction of one parabolic surface, are illustrated in the paper. A very useful field of application of the device is in the production of fast lenses. The performance of a triplet F/2·0 photographic objective with one parabolic surface approaches very closely that of a Tessar F/3·5. [It should be noticed that Figs. 6 and 7 have been interchanged in the paper.] J. W. T. W.

1114. *Natural and Magnetic Rotatory Power.* **R. Lucas.** (Comptes Rendus, 176. pp. 81–83, Jan. 8, 1923.)—The question is taken up whether, when an active substance is placed along the lines of force of a magnetic field, the rotatory powers are simply additive, or whether one effect is influenced by the other. Starting with Drude and Voigt's equations of motion of an optically active ion in a magnetic field, and introducing the Maxwell-Hertz equations, it is found that two circular vibrations are propagated through the medium with different velocities along the lines of force, and that there is a slight change in the magnetic rotatory power of the substance. It is doubted whether this difference could be detected by experiment. The effect is next considered from the point of view of the direction of the magnetic field, and an expression is found for the relative variation of the rotatory power, or $\Delta\rho/\rho$, a quantity of the order of 10^{-5} at the maximum. G. E. A.

1115. *Rotatory Power and Anomalous Dispersion of Tartaric and Malic Acids.* **R. de Mallemann.** (J. de Physique et le Radium, 4. pp. 18–42, Jan., 1923.)—The paper commences with an historical review of the subject, the work of Biot, Arndtsen, Wendell, Lepeschkin, Winther, Bruhat, Przibram, Grossman, and Pasteur being briefly summarised. Przibram found that the addition of certain organic liquids, benzene in particular, to alcoholic solutions of dextro-tartaric acid produced lævo rotations for yellow light, and the present author has verified this observation, finding also that solutions rich in benzene give lævo rotatory powers for all the colours of the spectrum, but afford a normal dispersion. A new cause of diminution of change of sign in the rotatory power is now described and occupies the 2nd section of the paper. Pasteur had pointed out that calcium tartrate in hydrochloric acid solution gave feeble negative rotation for the D line, and this action has been attributed by the present author to the formation of calcium chloride, a view confirmed by experiment. Under ordinary conditions solutions of tartaric acid are not precipitated by addition of calcium chloride, and the author has measured the rotatory power of a series of solutions of varying concentrations of tartaric acid and calcium chloride, constructing the dispersion curves for the 4 principal mercury lines. These curves are included in the paper and conclusions are drawn as follows: The presence of calcium chloride in a solution of tartaric acid considerably lowers its rotatory power, and lævo rotatory powers much greater than any previously observed have been obtained for dextro-tartaric acid. The lowering increases with the concentrations of the 2 bodies, but concentration variations of the salt have much greater influence; and when the calcium chloride is very concentrated, the effect is mainly due to it and depends very little on the concentration of the tartaric acid. The dispersion of the lævo rotatory solutions shows a normal course, and for the maximum lævo-effect its value is 2·22. The dispersion curves for mixtures poor in $CaCl_2$ bear a striking analogy to the dispersion curves for aqueous solutions of pure tartaric acid. Temperature has appreciable influence on the rotation, and, for the pure acid solution, elevation of temperature has the same effect as dilution. The work has been extended to other salts, *e.g.* the alkaline and alkaline earth chlorides and nitrates, the chlorides of magnesium and zinc, sodium sulphate and calcium bromide. The dispersion curves for the latter salts are included, from which is deduced that all these salts work in the same sense upon the rotatory power of aqueous solutions of tartaric acid but to very different degrees, *e.g.* chlorides > nitrates, but Na_2SO_4 has a very small effect compared with NaCl and $NaNO_3$. From the metallic standpoint the salts of calcium have the greatest effect, while $Ca > Sr > Ba > Mg > Zn$, and for the alkali metals, $K < Li < NH_4 < Na$. For ordinary (lævo) malic acid analogous phenomena occur in aqueous solution as with dextro-tartaric acid but in inverse sense, and this analogy also obtains in saline solutions. Curves are included in illustration. Experiments are described for neutral ethyl tartrate which in aqueous solution exhibits extremely

variable rotatory power, but in alcoholic solution much more constant values and its behaviour with $CaCl_2$ is very similar to that of tartaric acid itself, *viz.* a very strange inversion of the rotatory power. The 3rd section of the paper examines critically the various hypotheses, physical and chemical, proposed for the explanation of the anomalous dispersion of tartaric acid. The author concludes that the mixtures of tartaric acid and mineral salts contain two active bodies of opposite rotatory powers and different dispersions, which exist in varying proportion according to the concentration, temperature, and nature of solvent. Section 4 discusses the nature of these two bodies, whether isomeric or polymeric; or the result of dehydration, hydration being excluded. While favouring the idea of an isotartaric acid, the author finds himself unable to come to a definite conclusion, but he summarises the kind of experimental evidence which favours each particular hypothesis.
H. H. Ho.

1116. *The Tyndall Phenomenon in Liquids.* **R. Gans.** (Phys. Zeits 24. pp. 65–66, Feb. 1, 1923.)—After the diffraction of light by gas molecules had been definitely established [see Abstract 1677 (1921)], the author began to investigate the Tyndall phenomenon for aqueous solutions of cane sugar, this substance being chosen on account of its high molecular weight. In spite of the sugar molecules being essentially larger than those of gases, and so giving rise to a greater effect, the scattering of light being proportional to the 6th power of the molecular diameter, very conflicting results have been recorded, and Le Blanc even denies the existence of the Tyndall phenomenon in liquids. Divergencies can arise in two ways: (1) Through difficulties in the removal of foreign substances, a much harder task than for gases; (2) by ineffective optical methods. The author now describes what he opines to be a suitable apparatus for this purpose, and he adopts the procedure of Le Blanc and Wolski as appearing the most suitable. A photograph is reproduced by the author showing the pronounced Tyndall effect of an 18 % cane sugar solution alongside a very feeble effect for pure water. Both solutions had 0·5 % phenol added to them to prevent formation of microbe cultures. The author intends by further experiments to find whether the very weak Tyndall effect given by the pure water is due to traces of foreign substances or is characteristic of pure water, in which case it may be given by complex water molecules.
H. H. Ho.

1117. *An Entoptic Phenomenon.* **H. Dember.** (Zeits. techn. Physik, 4. 1. p. 7, 1923.)—Haidinger discovered two entoptic phenomena, one of which, the Haidinger polarisation brush, has often been described, but the second, the Haidinger Andrew's cross, has not been repeated. The author finds this to be an entoptic effect which may be produced by gazing for a long period at a whitewashed wall so as to receive only light which itself has been first reflected to the wall by a forest or a meadow from a low-lying sun. The effect consists of a 50′ dimensional ring which contains a cross with arms at right angles, and where ring and cross meet the effect is more intense. The colour of the entire figure is an intense chrome yellow, which with stronger illumination of the white wall rapidly fades away. The colour tone is much brighter than that of the Haidinger polarisation brush, which appears to the present observer as yellowish brown. The apparent dimensions of the figure are dependent on the distance away of the reference surface from the observer and the shape and position of the surface to the direction of vision. H. H. Ho.

1118. *The Visual and Photographic Albedo of the Earth.* **K. R. Ramanathan.** (Astrophys. J. 57. pp. 177–184, April, 1923.)—This subject, previously treated by H. N. Russell and C. G. Abbot, is here discussed afresh in the light of Luckiesh's recent measurements of the visual brightness of earth-areas as seen from an aeroplane and Raman's theory of the colour of the sea as originating from the molecular scattering of light in deep water. The effects of molecular scattering by the atmosphere and the sea are considered in detail with reference to the spectral distribution of the scattered light. The computed visual albedo comes out to be 0·46, and the photographic 0·58, in close agreement with the astronomical values 0·45 and 0·6 respectively. AUTHOR.

1119. *Dispersion of Air between* $\lambda\lambda$*4388–9224.* **E. Stoll.** (Ann. d. Physik, 69. 2. pp. 81–111, Nov. 2, 1922.)—Measurements of the refractive indices of air, electrolytic oxygen, oxygen from a cylinder of compressed gas, nitrogen, and carbon dioxide, were made using Jamin's method, in the region between $\lambda\lambda$4388 and 9224. The following formula was found to give good agreement for the values for air:

$$(N_0 - 1) \cdot 10^7 = 2871{\cdot}87 + 16{\cdot}170/\lambda^2,$$

where N_0 is the refractive index of air at 0° C. and 760 mm. of mercury, for a wave-length λ, measured in μ. The results are in good agreement with those obtained by other workers; a comparative table of the results obtained is given. An accuracy of 0·02 % is claimed for the absolute values of $(N_0 - 1)$, and 0·01 % for the relative values.

A. C. M.

1120. *Luminescence Phenomena and their Place in Technology. Part I.* **F. Schröter.** (Zeits. techn. Physik, 4. 1. pp. 2–7, 1923. Paper read before the Deut. Gesell. f. techn. Physik.)—Section 1 of this survey deals with the principle of temperature rise in connection with luminosity. The evolution of artificial sources of light is still based on the laws of temperature radiation, and the endeavour is always to increase the temperature of the luminous body. In this connection Section 2 discusses the ideal selective radiator [see Abstract 998B (1912)], and Section 3 considers the limitations of the ideal temperature radiator. Section 4 investigates emission and absorption during luminescence processes, and Section 5 compares the ideal with the real luminescence radiator. The conclusions drawn point to the necessity of a change in policy in lighting technology from the principle of temperature increase to the basis of selective radiation from suitable luminous bodies with technically accessible temperatures. For the ideal temperature radiator an expression for the resultant emission has been found, which has been tested on the behaviour of kathodo-luminescent calcium oxide. H. H. Ho.

1121. *Fluorescence Photography by Means of the New Wratten Ultra-Violet Filter.* **T. Svedberg and H. Anderson.** (Phot. J. 63. pp. 30–32, Jan., 1923.)—The importance of ultra-violet photography for photographing old parchments and for deciphering palimpsests, depends upon changes in the fluorescence of the different parts. In the usual methods exceedingly long exposures are found necessary. The paper describes the results obtained with a quartz vapour lamp and a kind of monochromator (Kögel), a silver filter (Kögel), and a Zeiss UV filter (Kögel, Svedberg, and Nordlund) and by the new UV Wratten filter.

The apparatus used for obtaining the photographs is described, briefly, and specimen results are given of the Codex Argenteus (which was written with silver and gold letters on purple dyed parchment, but now defaced). The Wratten UV filter gave perfect negatives, with an F/4·5 lens, in 15 min., whereas the Zeiss UV filter required 300 min.

The results of a spectrographic examination of the mercury lines showed that the Wratten UV filter transmits the lines 391, 366, 334 and 313 $\mu\mu$. The Zeiss UV filter is only about one-tenth the transparency of the Wratten in the long-wave region (from 391 to 334 $\mu\mu$), and differs in other respects. The value of such a source of ultra-violet light for fluorescent photography is considered to be a very great one, and examples of its possible utility in connection with the cataphoresis and diffusion of "colourless" substances such as proteins are mentioned. A. W. J.

1122. *Recent Advances in Photographic Theory.* **C. E. K. Mees.** (Eastman Kodak Co. Research Lab. Comm. No. 165. Frank. Inst., J. 195. pp. 1–21, Jan., 1923.)—An attempt is here made to summarise the recent work done by a number of workers on the theory of photographic sensitiveness, but no attempt is made to present a clear and definite creed drawn from these findings. The facts which have been ascertained are not yet sufficiently coordinated to be able to distinguish between the several explanations which are possible. A. E. G.

1123. *Factors which Determine Gamma Infinity.* **G. I. Higson** and **F. C. Toy.** (Phot. J. 63. pp. 68–73; Disc., 73–74, Feb., 1923.)—On account of its importance in the equation which represents the course of development of the photographic plate, γ_∞, the development factor at "infinite" development, is of great practical and theoretical interest in sensitometry. It varies enormously from plate to plate and with different developers; and though the factors which influence it have been separately studied by various investigators, hitherto no attempt seems to have been made to analyse their collective influence on γ_∞ itself. It is now shown that the effect of these various factors on γ_∞ itself can be summarised as follows:

Factor with which γ_∞ varies directly.

(1) Weight of silver per unit area—affecting D_∞.

Factors with which γ_∞ varies indirectly.

$$\left.\begin{array}{l}\text{(2) Effective specific gravity}\\ \text{(3) Absolute size of silver grains}\\ \text{(4) Ratio of gelatine to silver}\end{array}\right\}\text{Affecting } D_\infty.$$

$$\left.\begin{array}{l}\text{(5) Weight of silver halide per unit area}\\ \text{(6) Variation of silver halide grain size}\\ \text{(7) Absolute size of silver halide grains}\end{array}\right\}\text{Affecting T.}$$

The last factor is shown to be only approximate and not always true. It is also shown that factors (1), (2), (4), and (5) have very little influence on γ_∞ of ordinary commercial plates, which must therefore be governed mainly by factors (3), (6), and (7). The following general rule is suggested. The values of γ_∞ for ordinary commercial plates may be divided broadly into 3 classes according to the kind of grain: (1) Small grains, very uniform size. High γ_∞, greater than about 3·5 to 4. (2) Large grains, with widely divergent sizes; Low γ_∞, less than about 1·5. (3) Medium-sized grains, neither very uniform nor very uneven; (*b*) large uniform grains, or (*c*) small uneven grains. Medium γ_∞ from about 1·5 to 3·5. In the discussion Storr expressed the opinion that the factors controlling γ_∞ are more complicated than is here indicated. A. E. G.

1124. *The Size-Frequency Distribution of Particles of Silver Halide in Photographic Emulsions and its Relation to Sensitometric Characteristics. Part III.* **E. P. Wightman, A. P. H. Trivelli, and S. E. Sheppard.** (J. Phys. Chem. 27. pp. 1–51, Jan., 1923. Paper read before the Am. Chem. Soc., Sept., 1921.)—The present paper is a continuation of an investigation [see Abstract 870 (1922)] of the size-frequency distribution of photographic emulsions, both commercial and specially prepared, and the determination of the relations of the variations in grain size to the light sensitivity and other characteristics of the emulsions. In preliminary papers, some general aspects were discussed and some recent work by Svedberg considered, and it was pointed out that to obtain any relation of the grain, in the statistical sense, or dispersity, to the sensitometric properties of emulsions requires methods of assay and determination of the size-frequency curves. A description has been given of a fairly rapid but necessarily somewhat coarse sedimentation method, and the authors anticipated using the Oden sedimentation process, but a previous method of studying microscopically the size-frequence distribution of silver halide grains has been so much improved and rendered so much more rapid that the authors have adopted it, and the present paper contains its description in detail together with an estimate of the principal sources of error attending its use. Frequency curves and data are given for a number of typical emulsions ranging from the slowest to the fastest. It has been found that if frequencies (per 1000 grains) are plotted against sizes of grains an equation of the form, $y = y_0 e^{-kx}$ fits some of the data very closely, while for other data an equation of the form $y = y_0 e^{-k(x-a)^2}$ can be used to express the distribution of size variation. Here y represents frequency (per 1000 grains) and x the size of the grains. The distribution of total area of grains in each class (per unit area of the photographic plate) with the variation in class-size is of more importance photographically than the simple frequency distribution, and is obtained by multiplying each side of the above equations by the factor $N_x/1000$, where $N =$ total number of grains per cm.^{2} of plate. Empirical sensitometric characteristics for these emulsions have been obtained and are summarised in tabular form for comparison with the size-frequency data. The relative speed of the emulsions is found to increase rapidly with the increase of average size and range of size of the particles contained therein. Of the other characteristics, no definite statement can be made since these depend much more on the variation of other factors in the preparation and coating of the emulsions. H. H. Ho.

1125. *The Size-Frequency Distribution of Particles of Silver Halide in Photographic Emulsions and its Relation to Sensitometric Characteristics. Part IV.* **E. P. Wightman, A. P. H. Trivelli, and S. E. Sheppard.** (Eastman Kodak Co. Research Lab., Comm. No. 148. J. Phys. Chem. 27. pp. 141–166, Feb., 1923.)—In the preceding Abstract the experimental results of size-frequency measurements of a number of typical photographic emulsions and of the determination of their empirical sensitometric characteristics have been given, and the present publication discusses the theoretical bases for the correlation of this data. First, the authors investigate what relations may be anticipated from the photochemical theory of the characteristic curves, which latter represent the accumulation of the developed silver as a function of exposure, this in turn being a function either of increasing intensity or of increasing time, the other factor being kept constant. The existence and nature of statistical variation of sensitivity among silver halide grains is discussed, and a mathematical expression for photolysis in a homogeneous system is developed in relation to the density-exposure function. The relation of statistical variation of inertia to the density-exposure function is then discussed. It is concluded that under certain conditions the first derivative of the density-exposure function will correspond with the inertia-variation function or curve. Conditions permitting this correspondence are noted. If the size-frequency correspond with the sensitivity-frequency, then the curve of "reciprocal size-frequency" gives the inertia-variation curve, integration of which provides the density-exposure function. H. H. Ho.

1126. *The Coincidence Method for the Wave-Length Measurement of Absorption Bands.* **H. Hartridge.** (Roy. Soc., Proc. 102. pp. 575–587, Feb. 1, 1923.)—It was shown by Bryan and Baker that the coincidence method is one of the most accurate of visual methods of measurement. Their observations applied, however, to sharply defined lines of various types, and the present author has now found that nearly the same degree of accuracy is obtained when the lines set into coincidence are not sharp but have blurred edges. This method of direct visual observation forms the subject-matter of the paper, Section 1 of which contains the theory of the method. Section 2 gives a discussion of the optical principles involved when a spectroscope is designed in which two spectra are seen side by side, on looking down the eye-piece, but reversed in direction with one another. Under these circumstances the measurement of the mean wave-length of the absorption bands can be accurately carried out. The optical construction of the instrument is described in Section 3. The method of calibrating the micrometers of the spectroscope is given in Section 4, and experimental values are included to show the accuracy obtained. Section 5 contains the method for the quantitative estimation of pigments by the wave-length measurement of their absorption bands. The estimation is shown to depend on the movement of the band which occurs when the concentration of one pigment changes. An example of the method is given in Section 6, for the estimation of the percentage saturation of blood with CO gas by the measurement of the wave-length of the α-absorption band. The accuracy of measurement is found to be approximately 0·6 Å.U. In Section 7, the sources of error of the method are considered, and the probable accuracy of measurement discussed. The probable error of setting two absorption bands into coincidence is found to be but little greater than that of setting two sharp black lines into coincidence or of making one line bisect the area between two other lines. H. H. Ho.

1127. *Device for Colouring Flames.* **J. J. Manley.** (Phil. Mag. 45. pp. 336–337, Feb., 1923.)—Solutions are fed into a Bunsen flame by means of a "wick" of plantinum wires held in a small length of vitreosil tubing. This tube forms one limb of a **U**-tube arrangement, the other limb being blown out into a bulb in order to hold a large supply of the solution. A. C. M.

1128. *Visibility of Individual Spectra.* **F. H. Newman.** (Phil. Mag. 45. pp. 293–299, Feb., 1923.)—An electric discharge was passed through a mixture of the vapours of an alkali metal and mercury, keeping the temperature and so the partial pressures constant, and the nature of the discharge was varied. It was found that the relative brightness of the individual spectra produced changed considerably as the energy of the discharge was altered. A silica vacuum tube fitted with lead seals and having a capillary portion was used, and the mercury and alkali metal were maintained at 200° C. throughout the experiments by enclosing the tube within an electric heater. Photographs of the spectra obtained with mercury and Li, Na, K, Rb, and Cs respectively, are given, and the observations made are described.

When the vapours of mercury and any one of the alkali metals are present in a discharge-tube and the partial pressures are maintained constant, the spectrum of the alkali metal is always well developed with the ordinary discharge, but is completely masked by the mercury spectrum when the condensed discharge is used. All the alkali metal vapours have smaller ionisation and resonance potentials than mercury vapour, so that although the amount of the latter present is comparatively great, yet the electrons during their mean free paths between successive inelastic collisions are more likely to acquire the energy necessary for ionisation of the alkali metal atoms. As a result, the concentration of the luminous sources may be great enough to exhibit the spectrum of the alkali metal. With the condensed discharge and consequent increase in the electric energy a greater proportion of the Hg atoms will be ionised, because the colliding electrons will attain greater energy during their mean free paths. The mercury lines become very bright. At the high pressure used the mean free path is so small that it is improbable that the ionising energy can be obtained by impact alone and it is probably acquired partly by absorption of radiation. J. J. S.

1129. *Problems in the Variability of Spectra.* **T. R. Merton.** (Roy. Inst. Gt. Britain, [4 pp.] 1922.)—An account of some recent advances in spectroscopy. Whilst many variations in spectra can be referred to different compounds, to molecules, and to uncombined atoms in successive stages of ionisation, there are a number of other changes for which there is at present no obvious theoretical explanation. The possibility of some specific influence of one gas on the spectrum of another must now be recognised apart from the formation of chemical compounds which in the action of helium on the spectrum of hydrogen appears to be excluded. There is other evidence, based on a study of the broadening of spectrum lines, of a specific action on neighbouring atoms. J. J. S.

1130. *Theory of the Anomalous Zeeman Effect and Magneto-Mechanic Effect.* **A. Landé.** (Zeits. f. Physik, 11. 6. pp. 353–363, 1922.)—The theory of the anomalous Zeeman effect and its transformation in the Paschen-Back effect has been treated by W. Heisenberg from the point of view of the structure of the atom [Abstract 1612 (1922)]. The following are the assumptions made: (*a*) Half-and-half sharing of quanta between atom enclosure and atom central portion, (*b*) inactivity of the central impulse with regard to the space quanta arrangements in the magnetic field, (*c*) adjustment of the axis of the central impulse in the resultants of the outer and inner field not without wider combination with general principles. This assumed unmechanical adjustment of the atom nucleus in the resultants of the outer (H) and the inner field (H_i) produced by the luminous electron, in contradiction to the mechanically based hypothesis of Larmor, leads to the appearance of a turning-moment ΔM exerted upon the light-giving electron. ΔM excites a "work- and impulse-free" additional precession Δo around H and an additional rotation $\Delta \omega$ round H_i. This extra motion is obtainable according to the analogy principle from the empirical Zeeman types, and justifies with the help of Bohr's disturbance quanta distribution the apparently anomalous space distribution of quanta in the magnetic field which Heisenberg brought forward as a special hypothesis (*b*) beside the adjusting hypothesis (*c*). The special feature of the Zeeman term division may then be used for the establishment of the single impulse of the electron and leads clearly to Heisenberg's half-and-half partition of quanta (*a*) between core and luminous electron in the doublet-line atom. The anomalous extra-precession explains at the same time the anomaly of the Barnett and of the Einstein-de Haas effects. J. J. S.

1131. *Stark Effect on Hydrogen Secondary Spectrum.* **M. Kiuti.** (Japanese Journ. Phys. I. 3 and 4. pp. 29–39, 1922. In English.)—An investigation in the visible region, special attention being given to the Fulcher bands. The method employed was Lo Surdo's. The discharge tube was in the form of a Plücker tube, with one of the end bulbs removed. The capillary was 1 mm. in diameter. A continuous flow of hydrogen was maintained by an oil-immersed rotary pump. The gas was washed with water and conc. sulphuric acid, and entered a 2-litre flask; this flask was connected to the discharge tube by a capillary of 0·1 mm. bore and length 1 m. Another 2-litre flask between the pump and the tube helped to keep the pressure stationary. The length of the Crooke's dark space was about 2 mm.; this served as an indicator of pressure fluctuations. The portion of the capillary 2 mm. from the kathode was focused on the slit of the spectroscope, using two lenses; a quartz Wollaston prism placed between the lenses separated the *p*- and *s*- components. A plane grating with 590 lines per mm. was used; the dispersion in the first order was 31 Å.U. per mm. Owing to the arrangement employed, for many lines the image with no field was too feeble for use as a standard, and so a comparison Plücker hydrogen tube was used. Exposure was ½–2 hours. Two 5000-volt d.c. dynamos were used in series, with a 300,000 ohm manganin resistance in the circuit to make the discharge more stable. The terminal voltage of the tube was 4000 to 6000 volts, being kept constant during an exposure by regulating the exciting current to the dynamos. The intensity of the field was deduced from the separation of the Balmer lines; it was found that the present results were more nearly in agreement with Epstein's theory than Stark's results.

More than 100 lines are found to be affected by the strength of field used and under the present dispersion; most of these were on the long wave-length side of λ5300. In most cases the lines were displaced towards the red, or separated asymmetrically. The lines most affected were in the neighbourhood of λ5400 and λλ5930–5982. In all instances the separation increases either in proportion to, or more rapidly than, the field intensity. Between λ5300 and λ5700 the relative intensities of the Plücker tube and the positive rays are very different; *e.g.* the first and third members of the second Fulcher band are weakened in the positive rays as one goes out from the head, alternately. No simple rule was found for the Fulcher bands. In both bands the effect on the first and third members is large and small alternately; this may be of importance in deducing the structure of the origin of the secondary spectrum. Tables of results are given, and a photograph. A. C. M.

1132. *Light Radiation from the Gaseous Atom.* **A. C. Crehore.** (Phil. Mag. 45. pp. 34–64, Jan., 1923.)—The author investigates the effects of a negative electron passing near to a H-atom, but not colliding with it, on the basis of his model of the H-atom and the general expression, due to Saha, for the ponderomotive force which the passing electron should exert upon each of the electrons in the atom [Abstract 361 (1922)]. He finds that an initial velocity closely approaching that of light may be produced in an electron shot out from an atom in a straight line to a limited distance and returning to the atom. The energy so lost by radiation is no greater than that received from the passing electron, because it is entirely transformed into high-frequency vibrations of the positive charge, the whole energy of which, $MC^2 = 1 \cdot 49 \times 10^{-3}$ erg, is available for the time being, but is all returned to the atom. It therefore becomes possible for the energy of the passing electron to release a much larger amount from the atom—a trigger effect, which will be shown in a further paper to remove the usual difficulties connected with the photoelectric effect and secondary β-rays generated by X-rays, the two chief phenomena that seem to demand the artificial conception of "light quanta," which introduces more formidable difficulties than to admit a trigger effect. According to these results, the forces acting upon the electron at a given distance from the ion on the out and home journeys will differ greatly, showing that the force must be a function of the time as well as of the distance. The discordant results of attempts to find experimentally a law of force as a function of the distance only may here find explanation. It is found that the maximum distance attained by an ejected electron will be proportional to the wave-length of the resulting radiation, and will be $4 \cdot 677 \times 10^{-7}$ cm. for the shortest wave-length of the H-spectrum, about one-fourteenth of the average distance between the H-molecules at 0° C. and a pressure of 1 mm. of mercury. For the ejected electron to reach on an average, the adjacent molecule would correspond to a wave-length of about $12{,}760 \times 10^{-8}$ cm., which is not far from the second line of the Paschen series in the infra-red, so that practically the whole of the observed H-spectrum may be emitted before an electron travels so far, and therefore there will be no interference. The author is confident that the conceptions of a high-frequency vibration of the elementary charges themselves, regarded as quasi-solid bodies, and of radiated energy taking place in quanta because an electron is temporarily shot out from an atom and in most cases returns to it again, will prove fruitful in elucidating many phenomena now obscure. The derivation of the frequency equation of the H-line spectrum may be obtained very much as Whittaker has suggested [Abstract 1162 (1911)]. Attributing the spectrum to a gyroscopic connection between the two atoms of the H-molecule, he deduced the Balmer series. Instead of this connection being between the two atoms of the molecule, it would be, according to the preceding results, between the ejected electron and the remainder of the atom itself, *i.e.* the ion, for it is now quite certain that the atom is the source of these spectra. The author emphasises the probability that the results of this and his three preceding papers present the total energy content of the elementary positive and negative charges as of the utmost importance, as being the key to most atomic actions. G. W. DE T.

1133. *The Quantum Theory of the Simple Zeeman Effect.* **A. M. Mosharrafa.** (Roy. Soc., Proc. 102. pp. 529–537, Feb. 1, 1923.)—The aim of this paper is to put forward a theory of the simple Zeeman effect possessing the same general features as those of the corresponding theory in the case of the Stark effect developed by Epstein and Schwarzschild. These general features are: (1) The steady states of the atom are governed by classical dynamics subject to certain conditions, the quantum restrictions, which define the atom *both in the absence and in the presence of the field*; (2) radiation occurs during the period of transition from one steady state to another according to Bohr's energy relation $h\nu = W_m - W_n$. The essential difference between the author's treatment and the Bohr-Sommerfeld theory lies in this: that the relation between the motion of the atom, in the presence and in the absence of the magnetic field respectively, as defined by classical dynamics, is not assumed in the former, whereas it forms a fundamental part of the latter. This relation—referred to as Schott's theorem—involves a consideration of the motion of the atom during the period of establishment of the magnetic field, whereas the atomic system not being then a conservative one cannot be claimed as fully comprehended from the quantum point of view. The author's treatment, however, is not incompatible with Schott's theorem, but the latter follows as one of its consequences. As regards the quantum restrictions, the author employs the somewhat extended form suggested by Wilson to be applied to his original statement of these [Abstract 878 (1915)]. The object of the author's mathematical investigation is to show: (1) That if the original form of the quantum restrictions is maintained, both in the presence and in the absence of the field, then there can strictly be no difference between the energies of corresponding static paths in the two cases, and thus no theoretical ground for the spectral resolution; (2) that the extended form of the restrictions leads to the simple Zeeman effect. J. J. S.

1134. *Report on Fine Structure of Near Infra-Red Absorption Bands.* **H. Randall.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 45–57, Jan., 1923.)—A review of recent work on the structure of absorption bands in the near infra-red with special reference to HCl, water-vapour, and carbon-dioxide. The fine-structure of the CH_4 bands at 3·3 and 7·7 have been recently measured, and appear much simpler than those of water-vapour. A. C. M.

1135. *Ultra-Violet Absorption Spectra of the Alkaloids of the Isoquinoline Group.* **P. Steiner.** (Comptes Rendus, 176. pp. 244–246, Jan. 22, 1923.)—(1) The ultra-violet absorption spectrum of narcotine is determined by the benzene nucleus of its molecule; the isoquincline nucleus (hydrocotarnine) only displaces the absorption towards the red. (2) The spectrum of hydrastine differs from that of narcotine only by the displacement of the maximum and minimum towards the small wave-lengths, and by small differences in the intensity of absorption. (3) Hydrocotarnine which contains an isoquinoline nucleus partially saturated presents a spectrum formed of a single band in the ultra-violet and not at all resembling the spectrum of isoquinoline; moreover, it absorbs less strongly than isoquinoline. (4) According to the measurements made it is possible to detect spectrographically 0·07 mg. of narcotine or of hydrastine in 2(cm.)^3 of solvent. J. J. S.

1136. *Absorption Spectra of Aniline and the Toluidines.* **F. W. Klingstedt.** (Comptes Rendus, 176. pp. 248–250, Jan. 22, 1923.)—Using V. Henri's method of measuring the coefficients of absorption, and a continuous source of ultra-violet light, the spectra of these substances are found to be completely different from the results of previous workers. Aniline dissolved in hexane has nine narrow bands between $\lambda\lambda 2991$, 2704, and a wide band at $\lambda 2340$. The narrow bands are nearly equidistant, the separation $\Delta\frac{1}{\lambda}$ is about 450^{-1} cm. In solution in water, alcohol, and carbon tetrachloride, the narrow bands form one wide band.

Orthotoluidine has two wide bands; paratoluidine has seven narrow bands, and one wide one in the far ultra-violet. The ortho-spectrum is shifted 15 Å.U., and the para-spectrum 80 Å.U. with regard to aniline. Absorption curves are given for the three substances. A. C. M.

1137. *Absorption of a Series of Camphor Derivatives in the Ultra-Violet.* **A. Haller** and **R. Lucas.** (Comptes Rendus, 176. pp. 45–49, Jan. 8, 1923.)—The authors have previously found that certain camphor derivatives have higher values for dispersion, molecular refraction, and rotatory power than others produced by similar reactions. It is found that the first compounds all contain a double or ethylenic atomic linkage [Abstract 618 (1900)]. The present research shows that each of the compounds of the first class has a strong absorption band in the ultra-violet, the maxima varying for different compounds from 2900 Å. to 3500 Å. No such bands are found for the two compounds of the second class. H. N. A.

1138. *Some Radiations of Neon for Application to Metrology.* **A. Pérard.** (Comptes Rendus, 176. pp. 375–377, Feb. 5, 1923.)—The wave-lengths of the green cadmium line C_v, and five neon lines N_{r12}, N_{r4}, N_o, N_s, N_c, have been redetermined by the Michelson interferometer. The mean values obtained were:

	mμ.		mμ.		mμ.
C_v	508·58220	N_{r4}	609·61600	N_s	588·18910
N_{r12}	640·22460	N_o	594·48300	N_c	585·24840

The measured wave-length of each line varied systematically with the path difference. Curves are given from which corrections for this variation can be made, and from which indications of the complex structure of the lines are obtained. A. W. L.

1139. *Calculation of the Spectra Resembling Hydrogen from the Central Motion of the Electrons.* **E. Fues.** (Zeits. f. Physik, 11. 6. pp. 364–378, and 12. 1 and 2. pp. 1–12, 1922.)—Part I. The general type of the potential function in the central field of the atom is obtained by comparison of simple examples, and it is shown why the calculations hitherto made of the series constants could not attain their object. It is explained by graphical means how the true and effective quanta numbers or their differences, the quanta defects, are to be understood from the course of the potential function. Thence arise in agreement with experiment the following general rules: (1) The actual quanta effects are always positive and in the case of the lines running inwards very much greater than with those taking an outer course. (2) The Ritz correction of the term denominator $+ a \mid W \mid$ is for the lines going inwards < 0, for the outer > 0. (3) The quanta defect of a series decreases on passing over into the corresponding spark series in the case of the lines going inwards, with the outward-going ones it increases. The doubling rule does not hold for it. (4) Already the calculation of the spectrum of an idealisedNa-atom yields a quanta arrangement of the Na-term which is in contradiction to the usual hypothesis, but, on the contrary, agrees with the new Bohr hypothesis. This result is further considered in Part II of the paper.

Part II. It is established by means of a model and proved by calculation that approximately the terms of the Röntgen and the optical spectrum may be calculated from the motions of the electrons in one and the same central field. It is shown further how from the total spectrum of an element the potential curve of the atomic field can be obtained. The calculation is carried out for the Na-spectrum whereby its terms attain the significance of line energies of a calculable mechanical system. J. J. S.

1140. *Band Spectrum of Hydrogen.* **M. Kiuti.** (Phys. Math. Soc. Japan, Proc. 5. pp. 9–17, Feb., 1923. In English).—A "band" consists of three branches: the positive, null, and negative branches (Heurlinger's R, Q, and P series), which correspond to decrease, no change, and increase in angular momentum of the molecule by one or more quanta when the molecular configuration alters. A spectrum different from the ordinary vacuum discharge is obtained using the arc discharge in hydrogen; strong lines in the orange region fall into a series of form $\nu = a + bm^2$. This series corresponds to the null branch of a set in which the Fulcher bands are the positive and negative branches. The general arrangement is similar to Curtis's for helium [see Abstract 1606 (1922)]. The arc was struck in a glass bulb of 1·5 litres capacity, using a block of tungsten or other heavy metal as anode, and a kathode consisting of a bundle of tungsten filaments. The current was maintained by a dynamo in series with some cells, about 400 volts in all. The pressure was 2 to 3 atmospheres. Three stages were observed in the character of the arc, corresponding to different values of the current. In the first stage, weakest current, a uniform glow extends between the electrodes, consisting of the Balmer series, some secondary lines, and strong continuous radiation over the whole region. As the current increases, the glow gathers to the central line, and at 1·1 amps. a mass of red light appears suddenly along a central line, somewhat nearer the anode than the kathode, and there is a rise in the current and a drop in the terminal voltage. The continuous spectrum is much reduced, and the glow appears to be the same as the positive column of the discharge tube; on reducing the pressure, striations appear. The third stage begins at 1·8 amps.; the glow becomes an intense pink filament. The Balmer lines are very strong and broadened, as in the condensed spark; the secondary lines are strengthened, but new relative intensities appear, The kathode in this stage rapidly disintegrates. If the direction of the current is reversed, only the third stage appears. In all three stages, the secondary lines below λ5650 are feeble, and above it they are intense; but above λ5900 the third stage spectrum is different from the others and from any preceding photograph. Seven of these lines agree with the formula:

$$\nu = 17{,}206\cdot28 - 6\cdot8052\, m^2.$$

The first five numbers have been measured by Merton and Barratt; they record the fifth as appearing only when helium is present. If this set of lines is regarded as the Q series of a band, then Fulcher's green band corresponds to the R series of the same band, and Fulcher's red triplets to the P′ series. The other four series (S_4, S_5, S_6, S_7) of the red Fulcher band form the P series. Comparing with Curtis's values for helium, the moment of inertia of the hydrogen molecule must be about $\frac{1}{10}$ that of the helium molecule. This gives, as the distance between the nuclei, about $4\cdot6 \times 10^{-9}$ cm. A. C. M.

1141. *Series Relationships in the Arc Spectrum of Chromium.* **H. Gieseler.** (Ann. d. Physik, 69. 2. pp. 147–160, Nov. 2, 1922.)—Rydberg series are now obtained in the chromium arc spectrum, as a result of an investigation of the Zeeman effect, to which the theory of Landé [see Abstract 132 (1922)] was applied. Measurements were made on a plate obtained by S. Popow, using in air carbon electrodes impregnated with a mixture of silver and chromium nitrates. A field of 37,750 gauss was used. A second plate was prepared by the writer in a vacuum, using electrodes made of thin metal pressed from a mixture of powdered chromium and magnesium, and a field of 32,830 gauss. A third plate was taken in hydrogen at low pressure, without an applied magnetic field. As in the case of Ca, Sr, Ba, the $\frac{3}{2}a$ groups formed the key to the spectrum. Three such groups were found, each consisting of 12 lines, which could be arranged in a Rydberg scheme; these were found to be (p, p') in type. Two groups are found of the type (p, d') and another group (p, d''); they have nearly equal intensity in the arc and spark spectrum, and are therefore diffuse. A table is given of the Zeeman resolutions observed, compared with those calculated from Landé's theory, and the agreement is good. Another group is very strong, and some of the members appear in the flame, according to de Watteville [see Abstract 343 (1905)]. This group is taken to be a sharp series. In conclusion an empirical regularity is pointed out: the differences between the values for the factor g in Landé's theory for the d'' and D terms is exactly four times the differences in the values of g for the D and d' terms. A table of results for the measurements of the Zeeman effect is given, and compared with the calculated values. A. C. M.

1142. *Regularities in the Arc Spectrum of Chromium.* **A. Catalán.** (Comptes Rendus, 176. pp. 84–85, Jan. 8, 1923.)—Work on the spectrum of manganese [see Abstract 2411 (1922)] shows the diffuse triplets to consist of nine components, due to the diffuse term being quintuple. This is now shown to be true also of chromium. Several systems of series are present; two, termed the A and B systems, are tabulated. The two are practically identical, but displaced relatively by a constant ν . 4436·4. A. C. M.

1143. *Spectrum of Chromium.* **A. de Gramont.** (Comptes Rendus, 176. pp. 216–217, Jan. 22, 1923.)—A note to draw attention to the structure of the chromium spectrum deduced by Catalán [see preceding Abstract] fulfilling a prediction of the author's based on "raies ultimes," that the triplets λλ4289·72, 4274·80, 4254·34, and λλ3605·33, 3593·48, 3578·68 belong to the principal series of the arc and spark spectrum respectively. **A. Catalán.** (*Ibid.* pp. 247–248, Jan. 22, 1923.) Molybdenum is of great complexity, and contains several systems of series. A principal series $1s - mp$, a sharp series $2p - ms$, and a diffuse series $2p - md$ is given. The diffuse term is quintuple, and there are nine components in the diffuse series, while the principal and sharp series are triplets. Selenium contains a large number of diffuse triplets; more precise measurements will probably show the diffuse series to have nine components, the diffuse term being quintuple. Chlorine contains many triplets in the spark spectrum. More accurate wave-lengths are required, but observation of the present figures suggests a structure similar to those of the other elements of columns VI and VII of the periodic table. [See Abstracts 321 and 1434 (1910) and 678 (1923).] A. C. M.

1144. L *Series of Tungsten and Platinum.* **J. S. Rogers.** (Cambridge Phil. Soc., Proc. 21. pp. 430–433, Feb. 8, 1923.)—Many new lines have recently been discovered by Dauvillier in the L spectra of the elements of atomic numbers between those of tungsten and uranium. Experiments made by the author have confirmed the work of Dauvillier to a large extent, and afford evidence of several new faint lines of tungsten and platinum. A table is given showing the wave-lengths in Ångström units of the L lines of tungsten and platinum. The values generally agree with those given by Dauvillier and Coster, and are usually the average obtained from at least three films. Some lines have been omitted as probably due to impurities in the antikathode or to secondary radiations. J. J. S.

1145. *Carbon Arc Spectrum in the Extreme Ultra-Violet.* **F. Simeon.** (Roy. Soc., Proc. 102. pp. 484–496, Jan. 1, 1923.)—The agreement between the results of previous workers is not good, and so measurements of the wave-lengths in this region were made with a Hilger vacuum grating spectrograph. The instrument consisted of a metal tube, with a side-chamber for the introduction of drying agents. The grating was mounted on a carriage on slides, controlled by a screw, for focusing the spectrum on the plate. To the other end of the tube was soldered a casting carrying the plate-holder (which was made cylindrical, in order to force the plate into the same curvature as that of the grating), and also two slits, placed immediately below the dark slide, and recessed so as to lie on the same focal surface as the grating and the plate. The distance between the slits was arranged so as to give a range of about 800 Å.U. from either slit, with an overlap of about 80 Å.U. The shutter was operated by an external permanent magnet, and a plate 6 cm. × 1 cm. was used. The grating was a 4-inch Rowland of 101·5 cm. radius, a ruled area of 8·0 × 5·3 cm. and 596 lines to the millimetre. A water-cooled vacuum arc was employed, having electrodes of steel rod to which pieces of carbon were clipped. A tube was attached to the arc nearly opposite the slit, so that the arc might be evacuated otherwise than through the slit. Colour-sensitising the Schumann plates was found to improve their sensitiveness in the extreme ultra-violet. The pressure was kept the same each side of the slit, so as to obviate particles being drawn into the slit; in this respect more trouble was experienced in working with aluminium than with carbon. 7½ amps. drawn from the 220-volt mains were used. In order to keep down the intensity of the carbon-monoxide bands, the procedure was to expose the plate for ½ minute and then pump out for 5–10 minutes, and then expose again, making a total exposure in this way of about 5 minutes. The spectrum was thus photographed between 250 and 65 $\mu\mu$. A table of the wave-lengths is given and also those of previous workers. With a slit-width of 0·1 mm. it could be seen that the line λ1335 was double, and examination under the microscope suggested that several other lines were complex. Upon reducing the slit to 0·03 mm., λ1657 was seen triple and λ1561 double. The grating was then readjusted so as to give these lines in the second order on the plate, and the iron arc in air was used as a comparison. This photograph showed that λ1657 is a pair of doublets, the centre pair being very close.

The measurement of the wave-lengths was based on the second order comparison with the iron arc. A critical examination of the sources of error is given, and the second order measurements are estimated to be correct to 0·05 Å.U. λ1657 appears as two close pairs for the first time; groups have been found at λλ1329, 1260, 1194, 1036 and 651. Lines not previously observed in the arc spectrum are λλ1194, 945, 858, 687, 651, 640, 599, and 595, though Millikan found corresponding lines in the "hot spark" spectrum. A. C. M.

1146. *Spectrum of Active Nitrogen as Affected by Admixture of the Inert Gases.* **Rayleigh.** (Roy. Soc., Proc. 102. pp. 453–459, Jan. 1, 1923.)—Earlier investigations [Abstract 1339 (1911)] have shown that the usual spectrum of the nitrogen afterglow consists of a selection of the first positive nitrogen band spectrum. It is now shown that the selection can be modified by large admixture of the inert gases. There are three groups of bands, green, yellow, and red, and the effect of adding an inert gas is to shift the maximum of intensity in each group towards the red. Addition of helium especially makes the red group as a whole more intense at the expense of the others. The initial effect of adding helium, neon, or argon is the same, but an excess of argon produces effects different in detail from those produced by an excess of helium. It has not been determined whether these effects depend on something which occurs in the electric discharge or on something which happens later in the process of the afterglow. It is believed that the facts observed cannot fail to be of considerable significance. The spectra observed are reproduced in a plate of the photographic negative, but are more clearly illustrated in a diagram given in the paper which embodies all that can be seen in the original negative which the reproduction of the latter does not completely show. In addition to the main subject of the paper, evidence is recapitulated which shows the influence of carbon in developing the "cyanogen" bands. J. J. S.

1147. *Method to Distinguish between Arc and Spark Lines.* **W. Wien.** (Ann. d. Physik, 69. 5. pp. 325–334, Dec. 12, 1922.)—This is an investigation to determine whether light is emitted by charged or uncharged particles, made possible by the author's work on positive rays in a very high vacuum, when the electrical state of a particle will tend to persist. Positive rays pass through a slit into the high vacuum chamber; ¼ mm. from the slit are arranged plates of brass, with a small gap for the ray to pass through. Observations were made in the visible spectrum with two prisms of heavy flint glass, and in the ultra-violet with a quartz prism instrument.

Hydrogen.—No difference was found with or without a field of 2000 volts, with a pressure in the observation chamber of 0·0015 mm. Hg. The lines of the Balmer series are thus due to uncharged atoms.

Oxygen.—The spark lines were deviated towards the negative plate; the lines undeviated belonged to the series spectrum.

Nitrogen.—The displaced lines were all lines classified by Stark as spark lines, while those not displaced belong to the arc. Displaced bands belonged to the "negative" bands, while the undisplaced bands which were observed are part of the second "positive" group. Therefore the former are due to positively charged molecules, the latter to uncharged molecules.

Mercury.—A marked decrease in intensity was noticed. The series lines observed were not displaced, and so belong to the uncharged atom.

A. C. M.

1148. *Tesla Spectra and Fraunhofer Effect.* **J. K. Marsh** and **A. W. Stewart.** (Nature, 111. pp. 115–116, Jan. 27, 1923.)—The spectra were investigated which are produced by vapours of complex compounds subjected to waves from a Tesla transformer passing between two glass-coated electrodes. At ordinary pressure and the boiling-point, portions of the carbon spectrum only are emitted. On reducing the pressure, a regular set of six band-groups are observed, between $\nu = 3194$ and $\nu = 3752$, while traces of a seventh are observable beyond 3194. Each group is composed of four strong bands, accompanied by four weaker bands, followed by two broad weak bands. All the bands are related by the formula:

$$\nu = 98\cdot712\,n - \frac{98\cdot712\,m}{6}$$

where n is successively 33, 34, 35 . . . and m is 0, 1, 2 . . . . Comparison shows that this spectrum corresponds with a shift of 19 units to the full fluorescent spectrum of benzene, and also agrees with part of the absorption spectrum of benzene vapour, showing that the Fraunhofer effect occurs in the case of complex organic compounds.

A. C. M.

1149. *Spectra from Arcs in Different Media.* **St. Procopiu.** (Comptes Rendus, 176. pp. 385–388, Feb. 5, 1923.)—A continuation of a previous paper dealing with mercury [see Abstract 2281 (1922)]. This paper deals with the effect on the arcs of Cu, Au, Zn, Cd, Mg, Ca, and carbon, of immersion in air, hydrogen, coal-gas, nitrogen, water, and *in vacuo*. The arc was formed in a cylindrical vessel having a quartz window; the electrodes were mounted vertically, and the gap was controlled by a magnetic device; the upper electrode was attached to a small cylinder of soft iron, and a coil was wound round the outside so as to attract the iron upwards, and so break the arc. The region studied was λλ5000 ⟶ 2100.

In water, coal-gas, and hydrogen, arc lines are much widened, and terms of high order disappear. In Cd, Zn, Mg, Al, only the terms 1, 2, 3 of the sharp series ($1p - ms$) remain, and 2, 3, 4 of the diffuse series ($1p - md$). The Rydberg series ($1P - mD$) of Mg is weakened. Combinations suffer inappreciable change. Spark lines appear.

In nitrogen, the arc is more stable than in air, and arc lines are more numerous; the energy is displaced towards the higher terms. Many lines are reversed, *e.g.* the diffuse series of Al up to the ninth term, and the bands 3883, 3590 of carbon. Spark lines are reduced.

The Bunsen flame behaves as nitrogen in encouraging high order terms and producing reversal.

In "vacuo," the arc is very stable, particularly between 15 mm. and 1 mm. With less than $\frac{1}{2}$ ampere an arc having a gap 1 cm. was maintained. The high order terms are more intense than with nitrogen, and the energy moves towards the ultra-violet as the pressure is decreased. Many lines are reversed, particularly at the kathode; examples are given for Zn and Cd. The flame lines ($1S - 1P$) are weakened. The spark lines are very intense. The line λ4481 of Mg is found to be very wide and reversed. [*Erratum*, ibid. p. 792, March 12, 1923.] A. C. M.

1150. *Refraction of X-Rays in Calcite.* **B. Davis** and **H. M. Terrill.** (Nat. Acad. Sci., Proc. 8. pp. 357–361, Dec., 1922.)—Stenström has discussed the effect of refraction in X-ray spectra, and made some determinations of the index of refraction from the relative displacement of the several orders but, except in the case of sugar and gypsum crystals, the effect was too small for measurement. The present paper applies a modification of this method for calcite with the $K\alpha_1$ line of molybdenum. Stenström's equation is given, but the author's relations from the equation: $\nu = \cos\theta/\cos\theta'$, or $\sin^2\theta' = 1 - \nu^{-2}\cos 2\theta$, show that when δ is small the relation $\theta' = \theta' - \delta\cot\theta$ holds, and since values of θ can be directly measured for any characteristic line for several orders, either δ itself or its magnitude can be determined, or δ can be determined from the increase in apparent grating space with order from the equation:

$$\frac{n\lambda}{2\sin\theta_n} = d(1 - \delta\cot^2\theta_n)$$

But the former method is preferable. The apparatus used has been previously described. Measurements were made for the first three orders of the $K\alpha_1$ line, using a crystal of Iceland spar. The mean values of θ_1, θ_2, θ_3, within the experimental errors of $\pm 10''$ are given and then reduced to the corresponding first order angles, and three equations obtained to determine δ, giving a value of $\delta = 3 \times 10^{-6}$, which possibly contains large errors. An independent measurement of δ was obtained by a method due to Compton, measuring the angle of total reflection. This gave $\delta = 1\cdot 7 \pm 0\cdot 5 \times 10^{-6}$. A theoretical value calculated from Lorentz's equation gave $\delta = 1\cdot 85 \times 10^{-6}$. The authors suggest a modification of the method to determine refraction from the shift of the spectral lines, in which the face of the crystal is ground to the proper angle to the reflecting planes, and the shift would be increased sufficiently to make accurate measurements possible. B. J. L.

1151. *Flame, Arc, and Spark Lines from Arcs in vacuo.* **St. Procopiu.** (Comptes Rendus, 176. pp. 504–507, Feb., 19, 1923.)—A discussion of the properties of lines from metallic arcs *in vacuo*, with a view to discovering the difference in origin. Flame lines, $1S - 1P$, $1s - 1p_2$, are equally widened the whole length of the arc, whatever the current or the pressure of the gas. The lines $1S \rightarrow 1P$ are slightly wider at the anode (where the temperature should be higher), and do not suffer reversal. The two arc secondary series are short, strong, and widened at the kathode; at the anode they are long, weak, and fine. This effect is greater in elements of higher atomic weight. The ratio of the kathode width to the anode width in the same series increases with the order of the line. This ratio is reduced as the current is increased or the pressure diminished (between 40 mm. and 1 mm.). The kathode widening appears to be due to the higher concentration round the kathode of particles emitting the arc lines. As the pressure is reduced, this region extends towards the anode. According to Gouy, the greater the number of emitting particles the wider the line. Alternatively the widening may be considered as due to an intermolecular field (Stark-Lo Surdo effect). The author gives reasons for inclining to Gouy's hypothesis. Spark lines commence sharply at the kathode; they are strong, but shorter than the arc lines. They only show very feebly except at the kathode. Other spark lines appear at the kathode alone, and are shorter still. These are supposed to be due to doubly ionised atoms. For metals easily oxidised, *e.g.* Al, the spark lines appear at both electrodes, and are stronger at the anode. This is attributed to a film of oxide at the anode which might increase the anode fall of potential. The spark lines were strong at an anode of zinc covered with a film of oxide artificially. Bands are developed in the middle of the arc with weak currents; in the middle and at the anode with strong currents. Flame lines appear to come from particles uniformly distributed; arc lines from the neighbourhood of the kathode, and spark lines from the kathode or from particles leaving the anode when the metal is easily oxidised. [See Abstract 1149 (1923).] A. C. M.

1152. *Sector-Disc Used in X-Ray Measurements.* **J. A. Becker** and **F. W. Warburton.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 127–141, Jan., 1923.)—The energy in an X-ray beam entering an ionisation chamber may be varied by changing the current through the tube or by decreasing the cross-sectional area of the slit which limits the beam. There are serious objections to both these methods. The authors now demonstrate that the rotating sector disc can be used to vary the energy entering an ionisation chamber provided the speed of rotation of the disc is properly chosen. The best speed is 0·65 to 0·85 or 1·15 to 1·35 times the number of cycles per second furnished to the X-ray tube. Assuming that the energy in a uniform X-ray beam is directly proportional to its area, the law of the sector disc holds for X-rays to within an accuracy of 1 % for a 10° opening to 0·1 % for a 90° opening. A. B. W.

1153. *Relativistic Röntgen L-Doublets and the "Screening Constant."* **J. B. Green.** (Phys. Rev. 21. pp. 397–401, April, 1923.)—The screening constant in the relativity formula for X-ray L-doublet separations has been computed from the wave-lengths for elements of atomic number 74 to 92, in two ways, (1) using the complete formula, and (2) using only the first three terms (Sommerfeld's formula). The second calculation is found to give values more nearly independent of the atomic number than the complete formula, and is therefore to be preferred. This result is shown to be in agreement with a recent development of Bohr's correspondence principle, a suggestion by him that in such a series no term should be included which is smaller than the energy radiated by an electron per revolution, as calculated on the classical theory. The wave-length measurements, however, are not yet accurate enough to decide the question definitely. AUTHOR.

RADIO-ACTIVITY.

1154. *Changes in the Charge of an α-Particle Passing through Matter.* **G. H. Henderson.** (Roy. Soc., Proc. 102. pp. 496–506, Jan. 1, 1923.)—The velocity of a beam of α-rays, which is at first homogeneous, becomes unhomogeneous towards the end of the range; the author has shown that this "straggling" is much greater than that calculated from the recognised theory [see Abstract 2420 (1922)]. In the present experiments the source was generally a fine platinum wire, which had been exposed to Ra emanation; the slit was about 5 cm. away from this, and the Schumann photographic plate about 5 cm. beyond; these distances were measured to 0·1 mm. Absorbing sheets, usually of mica, were placed before the source; the air was pumped out, and the beam of α-rays which passed through the slit was deflected by a magnetic field. When there was no absorbing screen the normal deflected and undeflected bands were obtained; there was no appreciable sign of a band between the two. With a mica sheet equivalent to 1·42 cm. of air a very faint "middle" band appeared between the deflected and undeflected bands; and as the thickness of the mica was increased the relative intensity of this middle band increased, becoming equal to that of the deflected band at about 3 mm. emergent range. When the emergent range was less than about 2·5 cm. the separation became so great that contrast ceased to be a disturbing factor, and the middle band was exactly midway between the other two. It seems probable that the middle band is due to α-particles, which have gained an electron, and so are singly charged. The undeflected band has also been observed with low emergent range, when the magnetic field was kept on all the time; this seems to be due to a gain of another electron by the swiftly moving particles, which are converted into uncharged helium atoms. Rutherford has informed the author that a recent systematic counting of the scintillations on a zinc sulphide screen in the region involved showed a maximum at the midway point between deflected and undeflected bands, when the remaining range was 9 mm. This seems practically to decide that the middle band is due to singly charged α-particles. There was an appreciable darkening of the plate at a point corresponding to a velocity of 0·25 V_0. Apparently a lower velocity than 0·4 V has no effect on a zinc-sulphide screen, and so has not previously been observed. If the middle band is due to singly charged particles the minimum velocity is at least as low as 0·15 V_0. The hypothesis that the particles easily lose and gain electrons, when near the end of their range, offers a reasonable explanation of previously outstanding difficulties connected with this stage of their motion. H. N. A.

HEAT.

1155. *Dilatation of Aluminium-Magnesium-Silicon Alloys.* **A. Portevin and P. Chevenard.** (Comptes Rendus, 176. pp. 296–298, Jan. 29, 1923.)—Dilatation curves to various temperatures were taken of an alloy containing 0·95 % Mg and 1·25 % Si (*i.e.* 1·48 % Mg_2Si), and it is shown that the separation of Mg_2Si is marked by an expansion, its solution being, conversely, marked by a contraction. The increase in length with time and the age-hardening are shown to follow similar curves to each other, the phenomena of precipitation of the compound, age-hardening, and expansion being thus connected. J. L. H.

1156. *Structure and Heat Conductivity of Refractory Materials.* **M. Jakob.** (Zeits. Vereines deutsch. Ing. 67. pp. 126–127, Feb. 10, 1923.)—Different observers have found values of the heat conductivity of magnesite, some of which are twenty times as large as others; it is suggested that in the former cases the structure is crystalline, and in the latter amorphous; and it is shown that the change in conductivity with change of temperature follows the same path in the different observations as in the case of quartz crystals and quartz glass, in the first of which it falls for rise of temperature, while in the second it rises. H. N. A.

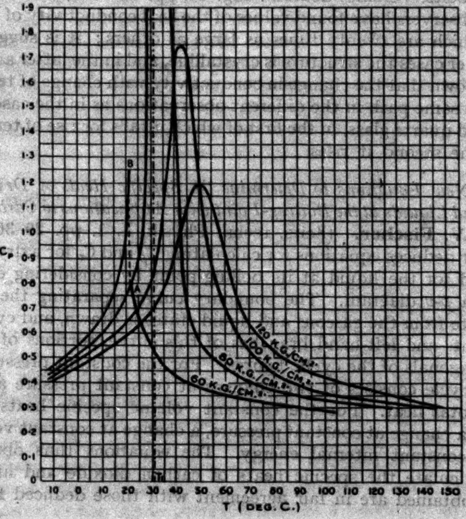
1157. *New Equations to Determine the Specific Heats of Dry Saturated Vapours and Liquids at the Boiling-Point with Applications to Carbon Dioxide and Air.* **V. Fischer.** (Zeits. techn. Physik, 4. 1. pp. 29–36, 1923.)—The author deduces equations for calculating C_p and C_v for a dry saturated vapour and for the liquid at its boiling-point by considering elementary cycles on a *p-v* diagram. The boundary curve separating the saturated vapour state from the gaseous and liquid states is drawn, and cycles taken on the right- and left-hand branches of this curve, portions of the curve forming diagonals of the cyclic figures. For the constant pressure specific heats the cycle consists of two changes at constant pressure and two of constant total heat. For the constant volume specific heats the cycle consists of a change at constant pressure, a change at constant volume, and two with constant internal energy. The equations thus obtained are used to calculate the specific heats of carbon dioxide and air, and the values so obtained are in fair agreement with those deduced from other equations. L. L.

1158. *Calculation of the Specific Heats of Dry Saturated Vapours and Liquids at the Boiling-Point.* **V. Fischer.** (Zeits. techn. Physik, 4. 2. pp. 72–76, 1923.)—In this paper, which supplements a previous contribution [see preceding Abstract] the author shows that an equation given in Planck's "Thermodynamics," *viz.*:

$$c_{ps} - c_{p\sigma} = \frac{dr}{dT} - \frac{\gamma}{T_s} + \frac{r}{s-\sigma}\left[\left(\frac{\partial v_s}{\partial T}\right)_p - \left(\frac{\partial v_\sigma}{\partial T}\right)_p\right]$$

and which is often used for calculating the specific heat of a dry saturated vapour (c_{ps}), is the difference of two equations, the one involving c_{ps}, the other $c_{p\sigma}$, the specific heat of the liquid at the boiling-point, either of which suffice for calculating these quantities. Analogous equations for the constant volume specific heats are also derived and a number of general relations between these specific heats. L. L.

1159. *Determination of the Specific Heats at the same Constant Pressure for the Liquid and Gaseous States of a Substance.* **V. Fischer.** (Zeits. techn. Physik, 4. 1. pp. 27–29, 1923.)—If a series of isothermals for unit temperature difference be drawn on a "Total Heat" (J), Entropy (S) diagram and these be cut by an isobar, the increment of J in passing along the isobar between two consecutive isothermals is the specific heat at constant pressure (c_p) at their mean temperature. Or, if on a (J, p) diagram isothermals be drawn, the intercept on an isobar between consecutive isothermals is c_p. From a Mollier JS diagram for carbon dioxide the author calculates in this manner the values of c_p at different temperatures and constructs as in the figure a c_p–t diagram for isobars above and below the critical pressure. It will be seen from this that the isobars for pressures exceeding the critical pressure are continuous and show a maximum value for c_p, which maximum is smaller the greater the pressure. The isobars below the critical pressure are discontinuous at the passage from the gaseous to the liquid state. The point A corresponds to the specific heat of the dry saturated vapour, B to that of the liquid at the boiling-point. For the same temperature, the value of c_p for the gaseous state increases with the pressure, but for the liquid state c_p diminishes with rise of pressure. The author also shows how from the isobars on a c_p–t diagram, the isotherms for a J, p diagram may be obtained. L. L.



1160. *Measurement of* $k = C_p/C_v$. **B. Tornau.** (Zeits. f. Physik, 12. 1 and 2. pp. 48–57, 1922.)—The ratio for carbonic acid at 0° C. works out at 1·3165 ± 0·00032. No perceptible influence of the pitch of the sound selected (Quincke's resonance method) could be detected between frequencies 256 and 1024. A. D.

1161. *Variation of Diathermancy with the Temperature of the Radiating Source.* **S. L. Brown.** (Phys. Rev. 21. pp. 103–106, Jan., 1923.)—The radiation from a tubular electric furnace was focused on a sensitive electrical resistance element (1 sq. mm. of thin copper oxide) which formed one arm of a Wheatstone bridge, the resistance of the element being 10,000 ohms, and its temperature coefficient − 0·01 ohm per 1° C. The substance to be examined was interposed between the furnace and the concave mirror which focused the radiation on the resistance element. The results show a decided increase of diathermancy with temperature for all substances examined except for clear rock-salt; and even this shows some increase. Moist air was examined by measuring the increased transmission through a brass tube with rock-salt windows at each end when the air was pumped out of the tube. For furnace temperatures of 400°, 700°, and 1000° C. the percentages transmitted are as follows: *Water* (0·5 mm.), 4·6, 14·4, 24·8; *rock-salt* (11 mm. clear), 85·6, 87, 89; *white mica* (1 mm.), 6, 14, 29; *glass* (1·2 mm.), 10·6, 22, 40. A column of *moist air* 2·5 metres long containing 0·032 mm. of precipitable water absorbed 8·7 and 7·1 per cent. for temperatures of 510° and 850° respectively. T. B.

1162. *Some Original Fusion Figures.* **M. Dieckmann** and **G. Gleissner.** (Zeits. techn. Physik, 4. 1. pp. 39–40, 1923.)—Occasional technical experiments on the heating of metal foil by high-frequency induction currents afforded a peculiar and unexpected fusion phenomenon which is now described with illustrations for copper, brass, lead, silver, and tin. Experimental details are also included. The general form of the fusion figures was found capable of regular repetition with the same materials, and appears to be characteristic of them. H. H. Ho.

1163. *A Comparison of the Normal Boiling Temperatures of Undesiccated Sulphur as Measured by the Dynamic and the Static Methods.* **A. W. C. Menzies.** (Am. Chem. Soc., J. 45. pp. 327–331, Feb., 1923.)—In the measurement of the boiling-point of a liquid, suppose that the liquid freshly condensed on the thermometer bulb, where it remains for but a few seconds, should even in part go over within these few seconds to a liquid of different boiling-point, then the boiling-point observed would be a function of the average duration of sojourn of the molten condensed sulphur upon the thermometer bulb. Boiling-point measurements have therefore been made on the same sample of sulphur with the same (platinum-resistance) thermometer using (*a*) the dynamic and (*b*) the static method. Differences of temperature of 0·01° at 450° could easily be detected, while pressure measurements were comparable within 0·2 mm. of mercury. For (*a*) the dynamic method the glass boiling tube containing the sulphur was jacketed by a resistance furnace at 250° C., the projecting lower end being heated by gas. All the usual precautions in determining the sulphur boiling-point were taken. For (*b*) the static method, the static isoteniscope [Smith and Menzies, Abstract 370 (1911)] was employed, submerged in a transparent bath of fused nitrates. In this arrangement the same specimen of sulphur remained for periods of minutes with a quiet surface in contact with the same specimen of vapour, except for the kinetic molecular interchange between vapour and liquid. When corrected to 760 mm. the boiling-point values obtained by the two methods (*a*) and (*b*) did not differ by more than 0·02° C. In a "discussion" of this result, the statement that delay may occur before a new phase, freshly formed, reaches its equilibrium constitution and properties, is examined for the cases of certain liquids and vapours. For example, Smith and Menzies observed that adequately desiccated calomel is without appreciable vapour pressure at 352° C., a temperature at which ordinary calomel shows a vapour pressure of about 350 mm. of mercury. Many similar examples have also been given by Baker [see Abstract 452 (1913)]. T. B.

1164. *Optical Pyrometer.* **U. Retzow.** (Zeits. Vereines deutsch. Ing. 62. pp. 179–181, Feb. 24, 1923.)—The optical pyrometer, employing an incandescent lamp the filament of which is placed in front of an opening in the furnace, is described, with the methods of obtaining a balance in the portions of the field of view illuminated by the lamp and by the furnace. Experiments to determine the effect of the distance between the pyrometer and the furnace are described, and it is shown that this distance can be increased to 2 or even 3 metres without loss of accuracy. The effect of dust and smoke in the air between the furnace and the pyrometer is considered, and experiments described on the effects produced by water-vapour and CO_2 in this space. There is very little physiological effect as between different observers. H. N. A.

1165. *Electric Heating of Calorimeters.* **W. P. White.** (Washington Acad. Sci., J. 13. pp. 17–28, Jan. 19, 1923.)—Systematic errors are diminished or removed if the calorimeter is used to compare two thermal quantities, one of which is a standard. The standard adopted should possess to the full the precision of the *comparative* calorimetric measurements and must be a quantity of heat. Of the two available standards, mechanical and electrical, the electrical is unquestionably of preponderant practical value. A single practised observer with good apparatus can do all the work alone if the calorimeter temperature is read electrically; very simply if a potentiometer can be used. A better way, for fluid-filled calorimeters, and heatings not over five minutes in length, is to calculate the average calorimeter temperature during the heating by means of observations made immediately before and after. The author gives a mathematical proof of the indirect method for finding the thermal head, and points out that the analysis is useful in giving an idea of the sources of error and the precautions that must be taken if there is an initial thermal head; *i.e.* a difference between calorimeter and jacket, or if the jacket temperature changes. If the jacket is electrically heated so as to give a nearly adiabatic method, its lag will be as important as the lag in the calorimeter. When the current is first turned into the heater the resulting change of temperature of the wire will generally cause an initial change of resistance, and the value of the first few seconds will be different from that measured. The question of dealing with unsteady batteries, and how the best results are obtained by some departure from standard procedure, is discussed. The author considers that the potential terminals should not be at the ends of the constantan wire, but outside the calorimeter altogether, at a point such that the heat generated in the lead wire between it and the calorimeter equals that flowing from the wire to the calorimeter. The errors connected with the leads and the precautions to be taken relative to these are described in detail. T. C. H.

1166. *The Lowest Temperature yet Obtained.* **H. K. Onnes.** (Faraday Soc., Trans. 18. pp. 145–174; Disc., 199–203, Dec., 1922.)—A detailed description is given of the apparatus employed by the author for liquefying helium and for attaining extremely low temperatures by evaporation of the liquid. The author considers that the lowest temperature hitherto attained by such means is some hundredths of a degree below 0·9° absolute. J. S. G. T.

1167. *Apparatus and Methods in the Leiden Cryogenic Laboratory.* **C. A. Crommelin.** (Faraday Soc., Trans. 18. pp. 175–196; Disc., 199–203, Dec., 1922.)—A detailed description is given of the apparatus and methods employed in the Leiden cryogenic laboratory for the liquefaction of gases, including air, nitrous oxide, methane, neon, hydrogen, and helium. Cryostats wherein extremely low temperatures may be maintained constant to within 0·01° by means of liquefied gases, *e.g.* hydrogen, helium, and neon are described. J. S. G. T.

1168. *The Generation and Utilisation of Cold.* **A. W. Porter.** (Faraday Soc., Trans. 18. pp. 139–143; Disc., 199–203, Dec., 1922.)—The thermodynamics of the production of cold by throttle expansion is briefly discussed. It is pointed out that in the case of expansion of a gas through a throttle, in addition to a *maximum* temperature, there is in most cases and probably in all cases, also a *minimum* temperature at which cooling takes place. In the case of carbon dioxide, this minimum temperature is about − 24° C., for a pressure about half the critical. *Liquid* carbon dioxide in this region behaves very nearly as a perfect gas. The various equations of state lead to the conclusions that at any one pressure there are two inversion temperatures if any at all, and that above a certain pressure heating in passing through a throttle is the universal rule at all temperatures. Experimental values of the inversion points for nitrogen and carbon dioxide are shown to conform with Dieterici's equation, modified as regards the power of γ in the index thus: $\alpha = \gamma \exp.\left[2\left(1 - \frac{1}{\gamma^{n}\beta}\right)\right] \Big/ (2\beta - 1)$ where $n = 5/3$, and α, β, and γ have the customary significance in the reduced equation of state. J. S. G. T.

1169. *Industrial Methods of Liquefaction and Practical Applications of Low Temperatures.* **K. S. Murray.** (Faraday Soc., Trans. 18. pp. 205–218; Disc., 264–273, Dec., 1922. Engineering, 114. pp. 509–510, Oct. 20, 1922.)—The extraction of oxygen from air by means of barium oxide, and Hampson's, Linde's, Claude's, and the Jeffries-Norton processes for the liquefaction and fractionation of air are briefly described. Assuming power to cost 1d. per b.h.p. the cost of oxygen produced in a Claude plant producing 500 cub. ft. per hour is 19s. per 1000 cub. ft., while in a plant producing 9000 cub. ft. of oxygen per hour the cost would be 4s. 6d. per 1000 cub. ft. If the plants were worked intermittently, the cost of oxygen produced by the small plant would be

27s. and by the large plant 6s. 3d. per 1000 cub. ft., the costs in every case being for gas into holder. In metallic Dewar flasks of 25 litres capacity and upwards, the loss of liquid oxygen due to ordinary evaporation does not exceed 5 % in 24 hours. The application of compressed oxygen in various directions is briefly referred to. The annual output in this country is about 300,000,000 cub. ft., of which about 96 % is used for industrial purposes, principally metal cutting, which absorbs about 50 % of the output, and oxy-acetylene welding, which utilises about 25 % of the output. J. S. G. T.

1170. *The Manufacture of Hydrogen by the Partial Liquefaction of Water-Gas and Coke-Oven Gas.* **G. Claude.** (Faraday Soc., Trans. 18. pp. 219–223; Disc., 264–273, Dec., 1922. Engineering, 114. pp. 506–507, Oct. 20, 1922.)—A plant for manufacturing hydrogen by the partial liquefaction of water-gas and coke-oven gas by throttle expansion is described. The machinery employed is lubricated with liquid nitrogen. The hydrogen produced is of sufficient purity to be employed for the synthesis of ammonia in a Claude hypercompression plant. Carbon monoxide, together with all the nitrogen contained in the original gas, and of 85 % purity, can be readily produced at the same time. The process requires compression of the gas to 15–30 atmospheres. The application of the process to coke-oven gas will effect recovery of benzol and ethylene. A plant suitable for the production of 1000 cub. metres of hydrogen per hour requires a sheaf of liquefaction tubes 40 cm. in diameter and 3 metres high. J. S. G. T.

1171. *The Heylandt Liquid Air Plant.* **A. J. Bremner.** (Faraday Soc., Trans. 18. pp. 240–242; Disc., 264–273, Dec., 1922.)—The plant designed by Heylandt for the production of liquid air is described. The special feature of the plant is the use of an expansion engine in place of the refrigerating and other pre-cooling devices customarily employed. The cooling effect achieved by expansion starting with the same initial temperature is more than double that given by Linde's formula. A small plant absorbs 1·4 kw.h. per litre of liquid oxygen of purity 96–98 % produced or 1·25 kw.h. per litre of liquid air containing 85 % of oxygen. The efficiency of liquefaction is about 20 %, *i.e.* 20 litres of liquid air are obtained from 100 litres of aspirated air. The efficiency achieved in other forms of plant is from 10 to 15 %. Liquid air plants operate at 200 atmospheres' pressure, while plants for producing gaseous oxygen operate at from 40 to 60 atmospheres. The capacities of the former range from 1 litre per hour upwards, and of the latter from 70 to 3,500 cubic feet per hour. J. S. G. T.

1172. *The Production of Liquid Oxygen for Use on Aircraft.* **E. A. Griffiths.** (Faraday Soc., Trans. 18. pp. 224–239; Disc., 264–273, Dec., 1922.)—Various types of vessels for containing liquid oxygen to be used for purposes of breathing in aeroplanes, etc., at high altitudes are described. These include containers insulated with materials of low thermal conductivity, and vacuum insulated containers, including glass, porcelain, and metal containers. Of the absorbents, charcoal and silica gel, employed for removing residual gases from the vacuum jacket, the former, while the more efficient, suffers from the disadvantage of inflammability. Silica gel is of lower density than charcoal and possesses about only half the absorbing power of the latter. Precautions to be observed in exhausting the vacuum interspace are briefly discussed. The rate of loss of liquid oxygen from commercial vessels amounts to about 70 % per day in the case of a vessel of 1 litre capacity, while in the cases of vessels of 3, 5, and 24 litres capacity the respective daily leakages amount to 15 %, 11 %, and 1·5 %. The origin of thermal leakage is briefly discussed as arising from conduction down the neck of the vessel, conduction through the residual gas, and radiation transfer between the walls. By the use of a radiation shield, the leakage of oxygen by evaporation may be reduced by about 15 %. The Heylandt vaporiser and a form of vaporiser due to the author, in which the rate of evaporation of liquid oxygen is controlled by the area of contact between the outside of the containing vessel and a copper pad carried by a flexible diaphragm adjustable by a screw and described. The "British Oxygen" laboratory plant, a plant built by the Liquid Air and Rescue Syndicate, and employing an expansion engine, and a portable plant working on the Claude system for producing liquid oxygen, are briefly described. J. S. G. T.

1173. *Thermometer Lag with Especial Reference to Cold Storage Practice.* **E. Griffiths** and **J. H. Awbery.** (Faraday Soc., Trans. 18. pp. 243–251; Disc., 264–273, Dec., 1922.)—The authors discuss the magnitudes of some of the possible sources of error in the determination of the temperature of a cold stores in a ship's hold by means of a mercury or spirit thermometer which is carried to the deck for purposes of reading. The effect of time-lag upon the reading of the thermometer is discussed in the case when the temperature is changing rapidly. J. S. G. T.

1174. *Some Materials of Low Thermal Conductivity.* **E. Griffiths.** (Faraday Soc., Trans. 18. pp. 252–258; Disc., 264–273, Dec., 1922.)—The following data relating to materials intended for purposes of cold storage insulation have been determined: *Expanded rubber* (soft variety), density, 0·059 to 0·12 c.g.s. unit; (hard variety), density, 0·17 c.g.s. unit; thermal conductivity of the material in sheet form 0·000 09 to 0·00012 c.g.s. unit; thermal conductivity of clippings packed 2·6 lbs. to the cubic foot, 0·000118 c.g.s. unit, and packed 4·0 lbs. per cubic foot, 0·000106 c.g.s. unit; *balsa wood*: density, 5·7 to 8·6 lbs. per cubic foot; thermal conductivity, 0·000113 to 0·000130 c.g.s. unit; *fibres of Kingia Australis* (wood): thermal conductivity, 0·000117 c.g.s. unit, when packed 8·4 lbs. to the cubic foot; *eel grass mats*: thermal conductivity when packed 9·4 lbs. to the cubic foot, 0·0001085; when packed 13·4 lbs. to the cubic foot, 0·000117 c.g.s. unit; *compressed peat*: density, 20 to 30 lbs. per cubic foot; thermal conductivity of former, 0·000176 c.g.s. unit; *peat treated with bituminous material* and weighing 29·5 lbs. per cubic foot; thermal conductivity 0·000173 c.g.s. unit. J. S. G. T.

1175. *Ethyl Chloride.* **C. F. Jenkin.** (Faraday Soc., Trans. 18 pp. 197–199; Disc., 199–203, Dec., 1922.)—The following are the physical data relating to ethyl chloride: boiling-point under atmospheric pressure, 12·5° C.; latent heat at 0° C., 93·7 cals. per grm.; specific heat of liquid at − 30° C., 0·348 and at 40° C., 0·413; the specific heat of the vapour similarly ranges from 0·22 to 0·28; the specific volume of the liquid is 1·035 c.c. per grm. at − 30° C. and 1·139 c.c. per grm. at 30° C.; the specific volume of the saturated vapour is 297 c.c. per grm. at + 20° C. and 1305 c.c. per grm. at − 20° C.; the critical temperature is 190° C., and the critical pressure is 54 atmospheres; in refrigerating plants it is important to keep ethyl chloride dry; pure glycerin must be used for purposes of lubricating plant employing ethyl chloride as a refrigerating agent; mixtures of ethyl chloride with large proportions of methyl bromide are non-inflammable. J. S. G. T.

1176. *Temperature of the Vapour Arising from a Solution.* **K. Schreber.** (Zeits. techn. Physik, **4.** 1. pp. 19–27, 1923.)—Faraday's assertion in 1822 that the temperature of the vapour arising from a boiling solution was that of the solvent boiling under the same pressure was a matter for controversy and experiment among certain physicists of the last century. This arose through the difficulty of conception of a discontinuity of temperature at the surface separating the solution from the vapour and the lack of experimental precautions to eliminate possible errors in the observation of the temperature of the vapour. The author discusses these points and accounts for the temperature discontinuity on thermodynamic reasoning when the existence of an osmotic pressure is recognised. He describes an apparatus he has used to determine the temperature of the vapour, in which the various possible sources of error are eliminated and Faraday's assertion experimentally established. L. L.

1177. *Regularities in Velocities of Evaporation.* **W. Herz.** (Zeits. Elektrochem. **28.** pp. 526–527, Dec. 1, 1922.)—Theoretically the velocity of evaporation G can be expressed by the formula $G = p\sqrt{M/T \times 2\pi R}$, where M is the molecular weight, T the absolute temperature, and p has the same value for every substance at the normal boiling-point T_s; thus the velocities of evaporation at the boiling-point are to one another as the values of $\sqrt{M/T_s}$. The values are calculated for a number of organic compounds; and relations are found, such as that in homologous series. These velocities increase with the molecular weight, and also when hydrogen is replaced by chlorine; bromine produces a larger increase and iodine a still larger one. H. N. A.

1178. *Radiation of Black Surfaces.* **H. Rubens** and **K. Hoffmann.** (Preuss. Akad. Wiss. Berlin, Ber. 27. pp. 424–435, 1922.)—The radiation from heated surfaces covered with lamp-black or platinum-black in layers of various thicknesses was measured, both as regards the total radiation and also with reference to the partial radiation from the ultra-red spectrum up to $\lambda = 118\ \mu$. The results obtained, which are summarised in tables, show that the substances tested, if in sufficiently thick layers, exhibit a high emission capacity. An "absolute grey" colour was indicated which in the portion of the spectrum investigated appeared specially suitable for emission and absorption surfaces. The permeability of lamp-black in a large portion of the ultra-red spectrum was determined. From the agreement of various measurements the maximum error may be assumed to be 0·5 %. J. J. S.

SOUND.

1179. *Velocity of Sound in Sea Water.* **E. B. Stephenson.** (Phys. Rev. 21. pp. 181–185, Feb., 1923.)—Over a distance of about 15,500 metres through the waters of Block Island Sound, New York, at 0·3° C., the velocity of sound was found to be 1453 meters/second, by determining the time for the sound wave produced by the explosion of a bomb to travel to each of five hydrophones anchored at widely separated points, and the distance travelled in each case. The depth varied from 18 to over 50 metres. The results from the five independent determinations for each of four bombs all lie within ± 0·2 per cent. of the average.

AUTHOR.

1180. *The Oldebroek Explosion, October* 28, 1922. (Nature, 111. pp. 32–33, Jan. 6, 1923.)—About 140 reports were received from observers in the British Isles. Of these, nearly one-third stated that despite careful listening no sound was heard that appeared due to the explosion. When the distribution of the positive and negative reports is studied, the most notable feature is the entire absence of positive reports from the greater part of the English Midlands. With regard to Europe generally, it appears that the sound was reported so far off as 850 km. to E.S.E., 600 km. to S., and 700 km. to N.W. of Oldebroek; whereas no single trustworthy observation was reported in a zone between the radii of 100 and about 180 km. Confirmation of the existence of a "silent region" was accordingly once more obtained. Further, the times which the sound waves took to reach various distances are in most cases longer than they would be for normal propagation through the surface air. In the case of the Biggin Hill (Kent) record obtained by W. S. Tucker, the first effect indicated a speed of nearly four times that of sound in air. This was attributed to propagation through the water and the ground.

E. H. B.

1181. *Short Sound Waves.* **K. Palaiologos.** (Zeits. f. Physik, 12. 6. pp. 375–378, 1923.)—The shortest sound wave which had up to date been investigated with certainty had a wave-length of 0·5 mm. according to Dieckmann. In the present investigation sound waves have been produced whose wave-length was as short as 0·170 mm. The method of producing these short sound waves was to superimpose on a direct-current arc a high-frequency oscillation of which the peak value of current was smaller than the current of the arc. Thus the arc current was made to fluctuate at a frequency equal to the frequency of the oscillating current and the arc becomes a source of sound. The high-frequency oscillations were produced by means of a thermionic valve with suitable circuit, this oscillator being capable of producing electromagnetic wave-lengths between 80 and 1500 metres. The measurement of the wave-length of the sound was made by means of diffraction gratings, two being used with periods of 1·86 mm. and 0·60 mm. The sound waves were focused on a concave mirror, then in a parallel beam on to the grating, then on another concave mirror which focused the sound on to a pressure apparatus for detecting the sound waves according to Lord Rayleigh's method. The wave-length is then determined according to the formula:

$$\lambda_a = \pm \frac{2p \cos \Delta}{k} \sin \phi,$$

where p is the grating period, k a whole number, Δ the angle of incidence, and ϕ the angle through which the grating must be rotated from perpendicular incidence in order to get the maximum effect on the pressure apparatus. The velocity of sound can be calculated from the formula $a = \lambda_a c/\lambda_e$, where a is the velocity of sound, c the velocity of light, and λ_e the electrical wave-length. The general result is that for acoustical wave-lengths from 1·71 mm. to 0·17 mm. the velocity is constant and equal to 335 metres per second at 0° C. J. R.

1182. *The Control of Pressure in a Reed Box.* **Z. Carrière.** (J. de Physique et le Radium, 4. pp. 11–17, Jan., 1923.)—The phonic turbine enables the instantaneous measurement of pressure for a mass of air in a state of vibration, and the present paper describes an application of this method to a reed box [see Abstract 603 (1922)]. The apparatus is very fully discussed, the paper being mainly concerned with mechanical details. H. H. Ho.

1183. *Indian Drums.* **R. N. Ghosh.** (Phil. Mag. 45. pp. 315–316, Feb., 1923.)—In India there are many drums which are musical and, like kettledrums, may be used with stringed instruments. These differ from kettledrums in two respects: (1) They are loaded over a central zone, and (2) they have harmonic partials. It is well known that the partials of an unloaded membrane do not form an harmonic series. A glance at an Indian drum shows that the load per unit area varies as we pass outwards from the centre. The nature of the vibration where the load varies inversely (1) as the first power and (2) as the second power of the distance from the centre is here mathematically determined. In the first case, surface density inversely as radius, the partials do not form an harmonic series, the chief effect of the variable loading is upon the absolute pitch of the membrane. In the second case, surface density inversely as square of radius, the partials form a series of odd harmonics and the absolute pitch is disturbed also. E. H. B.

1184. *Multiple Resonance.* **P. Rothwell.** (Nature, 111. pp. 254–255, Feb. 24, 1923.)—R. Paget's skilfully demonstrated lecture on October 18, 1922 [Abstract 1187 (1923)], is not less interesting as giving a very simple account of the nature and formation of speech sounds than as showing how far-reaching and diverse are the applications of multiple resonance in acoustics. The work of C. V. Boys in 1890 and that of Callender and Tucker in 1918 are then referred to. Following the last-named experiments, E. T. Paris showed how it was possible, by tuning the components of a double resonator, to obtain a resonance curve in which those of the components almost coalesce. Thus, instead of the single sharp peak as obtained from one resonant component, there occur two slightly separated peaks with very little droop between. It is sometimes a great advantage to get this broad, almost flat-topped peak in the resonance curve. The present author independently developed a form of *multiple* resonator for the recording system of the Gramophone Co., Ltd., of Hayes. This had almost a uniform response over four octaves (129 to 2069 vibrations per sec.). Perhaps multiple resonance will account for the remarkable evenness of response and characteristic quality of tone of good violins. E. H. B.

1185. *Hot-Wire Microphone and Applications.* **W. S. Tucker.** (Roy. Soc. Arts, J. 71. pp. 121–134; Disc., 134–137, Jan. 5, 1923.)—The hot-wire microphone was essentially a war invention. It has since developed into an instrument not only for detection, but also for measurement of sound and vibratory motion. It was first designed to detect enemy guns, and consisted essentially of a box or chamber, in one wall of which a small opening is made. When the explosive wave arrives at this opening, and makes there a small excess pressure, a blast of air is projected into the box. In the path of this blast a very fine platinum wire grid is mounted, and by means of an electric current the grid is heated to low incandescence. The effect of the blast is then to cool the wire, lower its electrical resistance, and so affect instruments (such as galvanometers of suitable type) that a clear indication of the blast is demonstrated. The blasts produced follow faithfully the pressure variations, and these are dependent on the nature of the source of the disturbance. Hence the record obtained is an indication of the character of an explosion and reveals the fact that heavy explosions consist in the main of very low-frequency sounds made up of a highly-damped train of waves. Amid various sounds, traffic, conversation, rustling of wind in trees, distant rifle and gun fire, the hot-wire microphone was shown to ignore all but the low-frequency gun fire. The paper is illustrated by over fifty diagrams, views, and photographic records. These render clear many important parts of the subject which an unillustrated abstract cannot reproduce. [See Abstract 1291 (1921).] E. H. B.

1186. *Electrophonographic Method of Recording Sounds.* **A. Blondel.** (Comptes Rendus, 175. pp. 1371–1374, Dec. 26, 1922.)—The author has elaborated a method of registering sounds which employs one or more microphones along with the Blondel oscillograph [see Abstract 2088 (1902)]. The method has been employed in the study of resonance in the microphones themselves, of the vibrations of rods and of bells above and below water, and for the recording of the sound of pistol shots. This method was therefore available at the beginning of the war for recording the reports of cannon. [See also Abstract 1141 (1912).] G. E. A.

1187. *Nature and Reproduction of Speech Sounds.* **R. Paget.** (Nature, 111. pp. 21–23, Jan. 6, 1923. Substance of lecture delivered at Univ. Coll., Oct., 1922.)—Observations made by the author on his own breathed vowel sounds, indicated that in *every* case the oral cavity as a whole, from larynx to lips, actually gives *two* simultaneous resonances for *each* vowel sound. It appeared that these pairs of resonant notes are not quite fixed in pitch for any one vowel sound, but might vary over three or four semitones, without a very appreciable change in the character of the vowel. A chart is given of these double resonances for the vowels in *ea*t, *i*t, h*a*y, m*e*n, h*a*t, *ea*rth, sof*a*, *u*p, c*a*lm, n*o*t, *a*ll, n*o*, wh*o*, p*u*t, all as uttered by the author. All these resonances are included between 304 and 2580 per second. Taking the vowels in the above order, we have at first the two resonances at the extreme limits, then the higher ones fall and the lower ones on the whole rise for a time, and then they also fall near the end of the series. In confirmation of the theory the author has formed that these resonances are due to the associated cavities (or coupled vibrators) of the mouth and pharynx, resonators have been formed in plasticine to respond to the pitches needed for the various vowels, and the vowels are then obtained by breathing through them. The two cavities may be either in series or in parallel. **E. H. B.**

1188. *Minimum Audible Intensity of Sound.* **C. M. Swan.** (Am. Acad., Proc. 58. pp. 425–441, May, 1923.)—After reviewing various previous investigations at some length, the author describes his own plan carefully arranged to obviate the possibility of errors inherent in them. The source of sound consisted of a circular aluminium diaphragm, free at the edges, vibrating in a circular aperture in the door of the room, the diaphragm being attached to one prong of a tuning fork outside the door. The time of decay of the sound was measured by a stop-watch so arranged that it began to record at the instant the source of sound was stopped, and continued to record until stopped by the observer when the residual sound in the room reached the limit of audibility. It was then calculated what was the limit of minimum audible energy in ergs. per sq. cm. per second for a number of pitches and for two observers, indicated by M and N. The highest result given is 8×10^{-5} ergs. cm.$^{-2}$ sec.$^{-1}$ for a sound of 121 per second heard by M. The lowest result is 7×10^{-10} ergs. cm.$^{-2}$ sec.$^{-1}$ for a sound of 493 per second, heard by N. Valuable graphs are given comparing the results by various investigators. **E. H. B.**

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1189. *Electric and Magnetic Units.* **F. Emde, J. Wallot.** (Elekt. Zeits. 44. pp. 175–177, Feb. 22, 1923.)—This paper has been written in response to a previous publication on the subject of units by Wallot [see Abstract 259 (1923)], and is not intended to contradict the latter's proposals but to affirm that these should actually be used in practice. In Section 1, student difficulties with respect to units are considered, *e.g.* How can a student understand that c.g.s. units of two kinds are possible for every electrical quantity, unless he be instructed as to the arbitrary assumptions? Section 2 considers units from the standpoint of practical electro-technology. The author states that the practical units have nothing to do with the c.g.s. units, *e.g.* according to Grüneisen and Giebe 1 Ω is not $= 10^9$ c.g.s., but $1 \cdot 00051 \times 10^9$ c.g.s. Section 3 criticises dimensional formulæ, while the connection between electric and magnetic units is discussed in Section 4. The author considers a convenient unit for magnetic induction to be the volt . sec./$m^2 = 10^4$ gauss. Section 5 deals with the absolute dielectric constant and permeability. Emde heartily recommends Wallot's proposals to all interested in both theory and practice.

Wallot has contributed a reply to the suggestions made by Emde, which deal mainly with minor points, *viz.* the mass system, and the assertion that physical equations are statements with respect to physical quantities. He asserts that when the two convictions are compatible, *viz.* that the content of a physical equation does not depend on the accidental choice of the system of units, and that one can only calculate with numbers, then must certain power products of certain quantities be dimensionless, *i.e.* certain equations of units must exist. This is the kernel of the whole theory of dimensions. The paper concludes with some numerical corrections. H. H. Ho.

1190. *Relativity Electromagnetic Theory.* **P. Dienes.** (Comptes Rendus, 176. pp. 238–241, Jan. 22, 1923.)—A proof by tensor analysis is advanced in support of Einstein's contention that Weyl's electromagnetic theory does not constitute an advance towards the solution of the fundamental problem of the derivation of electromagnetic forces by purely geometrical processes. J. S. G. T.

1191. *Lines of Electric Force of a Moving Charge on the Emission Theory.* **F. E. Hackett.** (Phys. Rev. 21. pp. 465–472, April, 1923.)—The author describes a simplified method of determining the lines of force of a moving electric charge, on the emission theory of Page and Bateman. This theory supposes that the charge emits streams of elements which move with the velocity of light, and constitute the lines of force. It leads to a vector equation for the directions of emission. By a transformation

a simpler vector equation is derived from which the solutions previously given for variable rectilinear and uniform circular motion are more easily obtained. These solutions are both shown to conform, each in a special way, to the Einstein law of composition of velocities for uniform motion.
AUTHOR.

1192. *Applications of Functions with Multiplicative Periods.* **J. Kunz.** (Phys. Rev. 21. pp. 186–194, Feb., 1923.)—Has reference to potential around a long charged wire between two earthed concentric cylinders.
AUTHOR.

1193. *Influence Machine Current.* **H. Hermann.** (Zeits. techn. Physik, 4. 1. pp. 14–18, 1923.)—Criticises the work of Rossetti and Müller on the current produced by a Holtz machine and gives an account of results obtained with a machine similar to that used by Rossetti. The experiments lead to a characteristic formula for the current strength J, *viz.* $vB/(W'/n + W_a)$. B is the potential difference between the coatings, E the electromotive force, $(E = vB)$ W'' is the internal resistance for n rotations per sec. $(W' = W''/n)$, and W_a is the external resistance.
L. L.

1194. *The Electric Field at the Edges of Plate Condensers.* **W. Rogowski.** (Archiv f. Elektrot. 12. pp. 1–15, March 10, 1923.)—A mathematical article dealing with the field in the neighbourhood of the edges of plate condensers, where the edges have various (rounded) shapes.
E. M.

DISCHARGE AND OSCILLATIONS.

1195. *Lichtenberg's Figures as Related to Theory and to Practice.* **K. Przibram.** (Elek. u. Maschinenbau, 41. pp. 97–99; Disc., 99–100, Feb. 11, 1923.)—Figures similar to those discovered by Lichtenberg can be produced by placing discharging electrodes directly on the sensitive film of a photographic plate, which is then developed. The figure obtained depends on the sign of the charge, the voltage, the rate at which this is applied, the material used, the composition and the pressure of the gas, and the dielectric constant of the insulating plate. The figures are of some pathological interest, since similar figures are sometimes found on the skin of persons struck by lightning; they sometimes appear as a disturbing effect in X-ray practice, and may be used in the study of cases that occur in high-tension work, the corona, the most suitable form for high-tension insulators, etc. They also may give a simple method of measuring high voltages, as to photograph them would not greatly alter the electrical relations in the circuit in the same way that the ordinary method of measuring the length of a spark in parallel does. Pedersen has evolved a method for measuring very short times by means of these figures, and Bizold discovered electric waves in wires with their help seventeen years before Hertz discovered them. The figures are due to the ionisation produced in the gas by rapidly moving ions and electrons when the discharge takes place, and the difference between their form about the positive and negative electrodes, and in different gases, at different pressures can be explained in this way.
H. N. A.

1196. *On the Different Aspects of the Electric Discharge in Crystals.* **G. Reboul and P. Blet.** (Comptes Rendus, 176. pp. 86–88, Jan. 8, 1923.)—Studies made upon the electric discharge through crystalline bodies and generally through feeble conductors, fall into two classes: (1) Conductivity proper, (2) real disruptive potential as made by engineers for the rupture of industrial insulators. Between these extreme aspects of electric discharge are a series of diverse cases which have hitherto escaped attention, and which became prominent in a recent investigation [see Abstract 1149 (1921)] concerning feeble conductors. The experiments are fully described and are easy to repeat. In an opaque box whose ebonite lid is furnished with two piston electrodes, a photographic plate is placed and above it a transparent plate with parallel faces, such as a quartz plate 3 mm. thick. The two electrodes rest on the latter and are connected either to the terminals of an electrostatic machine or of a battery of small accumulators, or of an induction coil, means being provided for varying the electric tension. Different periods are employed and the following three aspects described and accompanied by diagrams: (1) About the positive pole are a series of concentric and equidistant circles, generally three or four in number, but considerably increased for very long periods. This explanation for this phenomenon is identical with that given by Cornu for the haloes of thick plates, and from the distance between two annuli the refractive index of the plate may be calculated. This experiment provides a rapid means of determining refractive indices. Other sources of light may be used, such as the mercury arc. (2) By changing the tension which produces the electric discharge, the concentric circles may disappear, and be replaced by a series of sharp circular spots of the equal diameter separated from each other and distributed without any apparent law. The diameter depends only on the thickness of the plate and on its index of refraction. This aspect appears due to a pencil of rays having the form of a circular cone whose apex is at the upper face of the plate and whose angle is the limiting angle. Here again the limiting angle and refractive index of the plate may be calculated. (3) Finally, if the plate is crystalline and a further change of tension be made, a figure is obtained whose shape depends on the relation of the faces to the axes of the crystal, *i.e.* on its symmetry.
H. H. Ho.

1197. *Ionisation of Mercury-Vapour in Presence of Argon.* **G. Déjardin.** (Comptes Rendus, 175. pp. 1203–1206, Dec. 11, 1922.)—When a mixture of helium and mercury-vapour is traversed by electrons of increasing velocity, the mercury is ionised as soon as the potential accelerating the electrons exceeds the first critical potential of helium (20·4 volts); and the arc and spark spectra of the mercury are remarkably modified. With argon, on the other hand, there appears to be a first critical velocity at 11·1 volts and ionisation of the mercury then sets in; but the mercury spectrum is hardly affected. A. D.

1198. *Ionisation by Collision.* **J. S. Townsend.** (Phil. Mag. 45. pp. 444–456, March, 1923.)—It is shown that the author's theory of ionisation by collision (see "Ionisation by Collision," Townsend) in which the principal effects attributed to ionisation of molecules of gas by impacts of electrons and positive ions is the only one which affords a consistent explanation of the principal properties of the disruptive discharge between parallel plates, the glow discharge from a cylindrical surface, and the development of the smaller currents between parallel plates. The paper deals with recent experimental evidence and with various criticisms of the theory. A. B. W.

1199. *A Demonstration Experiment of the Magnetic and Electrical Deflections of Kathode Rays.* **E. Mauz.** (Phys. Zeits. 24. pp. 70–71, Feb. 1, 1923.)—The experiment now described illustrates how the electrical and magnetic deflections of kathode rays depend on their velocities, and gives the practical consequences for the Braun tube. The sensitiveness of the Braun tube is shown to be inversely proportional to the velocity for magnetic deflection, and inversely proportional to the square of the velocity of the kathode rays for electrical deflection. When, therefore, the vacuum is increased for obtaining the maximum brightness of figures on the screen, and, consequently, the velocities of the kathode rays augmented, the electrical deflection is much more sensitive than the magnetic. Accordingly an experiment has been based upon this behaviour in which the magnetic and electrical effects are produced in vertical and horizontal directions respectively. Photographic figures can then be obtained of the pencil of kathode rays, of which specimens are included in the paper, and the changes of velocity with alterations in vacuum demonstrated. H. H. Ho.

1200. *Theory of Thermionic Currents.* **R. Gans.** (Ann. d. Physik, 69. 5. pp. 385–408, Dec. 12, 1922.)—Given the geometrical arrangement of the electrodes in an evacuated electron tube, the temperature of the glowing kathode, and the p.d. between anode and kathode, it is required to find the potential distribution and the current strength. From the potential distribution the spacial distribution of the field strength and of the charge, as well as that of the energy density, follows at once, and the characteristic of the tube can then be obtained from the function expressing the current strength in terms of the p.d. The present paper gives theory relative to the above, assuming the system to be cylindrical, and neglecting electron impacts, reflection, and secondary radiation, which will be dealt with in a subsequent paper. [See Abstracts 843 (1908) and 700 (1921.)] A. W.

1201. *A Simple Experiment to Demonstrate Thermionic Emission in a Glow-Lamp.* **H. Greinacher.** (Zeits. techn. Physik, 4. 1. pp. 9–11, 1923.)—The bulb of the lamp (metal or carbon filament) is well cleaned and dried and a strip of tinfoil fastened round the outside, filament and tinfoil forming the plates of a condenser. The tinfoil is connected to a graduated electroscope (Braun electrometer) the case of which is insulated. By means of a key the case may be either earthed or connected to a source of potential (± 2000 volts). Connecting the case to the + voltage supply and noting the deflection of the electrometer leaf, this is seen to increase when the lamp is switched on (d.c. or a.c. may be used). Negative ions pass to the inner side of the glass bulb, the effective capacity of the lamp as a condenser being increased. Emission of positive ions can also be demonstrated by connecting the electrometer case initially to the + voltage supply. The rate of emission can be studied for various temperatures of the filament by including an adjustable rheostat in the lamp circuit. A simpler method of procedure is to earth the case of the electrometer and charge the leaf with an electrified rod, when the potential of the leaf gradually falls on switching on the lamp. The choice of method depends on the relative capacities of the electrometer and lamp. Curves are given in the paper showing variation of potential of electrometer leaf, with time for different temperatures of the filament and for two types of lamp. L. L.

1202. *Solution of the Representative Differential Equation of the Triode Oscillator.* **E. V. Appleton** and **W. M. H. Greaves.** (Phil. Mag. 45. pp. 401–414, March, 1923.)—The equation considered is $d^2v/dt^2 + f(v)dv/dt + \omega^2 v = 0$, where $f(v)$ is a power series in v. Periodic solutions are obtained which correspond to the "stationary states" of the system. A. W.

1203. *Effect of Gases in Facilitating the Passage of Current from an Electron-Emitting Source in Crossed Electric and Magnetic Fields.* **O. W. Richardson** and **R. Chaudhuri.** (Phil. Mag. 45. pp. 337–352, Feb., 1923.)—It is well known that the passage of electron currents in vacuum tubes is stopped by the application of comparatively weak magnetic fields in directions perpendicular to the electric intensity. If, however, a trace of gas be admitted, so that the vacuum is no longer perfect, the current will flow again, although its magnitude will in general be less than that obtained in the absence of the magnetic field. The most interesting results of the present investigation are the comparatively large magnitudes of the currents in the magnetic fields, the proportionality of these currents with the gas pressures, and the relative magnitudes of the effects in air and in nitrogen. These data would seem adequate to settle the nature of the phenomena in its main outlines. The fact that the residual currents are of similar magnitude in air and nitrogen suggests that the formation of heavy ions is a relatively unimportant factor. If it were important, we should expect the effect to be much more marked in air, since oxygen is a much more electronegative gas than nitrogen. This leads to the conclusion that the passage of the currents in the magnetic field is a test of a collision between an electron and a gas molecule simply, and not of a collision which results in combination of the two to form a heavy ion. The proportionality between the residual current and the gas pressure seems at first sight a difficulty on this view, on the ground that the co-operation of more than one collision is required for an electron to reach the anode. This suggests that the effect might be expected to increase more rapidly than as the first power of the pressure. It is probable, however, that this view of the phenomena is too superficial. The first collision will readily decide the fate of the electron, because it puts it in a condition which prevents it from being returned to the kathode by the magnetic field. Since the experiments deal with a steady state, there is no opportunity for indefinite accumulation of electrons or ions in the field; so that the only alternative is for the electron to reach the anode. If the gas present is inadequate to ensure this by means of collisions, it seems likely that the electrons present in the space will cause a readjustment of the electric field in such a way as to make this possible. On this view, the currents to the anode in a magnetic field will be proportional to the probability of a single collision, and therefore proportional to the gas pressure, for small pressures. The actual magnitudes of the currents in a magnetic field are also consistent with this point of view. On the assumption that the occurrence of a single collision is sufficient to determine the passage of an electron to the anode an estimate is given for the value of the mean free path of an electron in the gas. If this interpretation of the phenomena is substantiated by further experiments, it would seem that the method might be used to compare and perhaps to measure the mean free paths of electrons in different gases. Further experiments extending to a number of gases are in progress.

A. E. G.

1204. *Coupled-Vibration Systems of Single Frequency.* **A. Kalähne.** (Ann. d. Physik, 69. 6. pp. 439–472, Dec. 19, 1922.)—This is the continuation of an investigation of which the first instalment appeared in 1913 [see Abstract 327 (1914)]. The treatment is mathematical, and after obtaining the simultaneous differential equations of motion and deriving the auxiliary equation, the conditions are sought which will give a single frequency. A special feature is the various possible couplings that are dealt with. Thus three types of simple coupling are recognised, *viz.* magnetic or acceleration coupling, current or friction coupling, and electric or force coupling. There are then three cases in each of which *two* of the simple couplings are present, and lastly a seventh case in which all three are present. These unusual cases, especially those of mixed couplings, are mathematically treated and formulæ derived and numerical results obtained and tabulated. E. H. B.

1205. *Selective Absorption of Electric Waves in Dielectrics.* **W. Romanoff.** (Ann. d. Physik, 69. 2. pp. 125–146, Nov. 2, 1922. Paper read before a meeting of the Moscow Phys. Gesell., March, 1917.)—A method is here described by means of which the absorption of electric waves in small quantities of fluid can be determined. A thermo-element is constructed for registering the heating of the fluid which has been caused by the absorption of the electric waves; this is a convenient method and free from the influence of troublesome induction currents. The absorption of weak, damped electric waves in alcohols of the fatty series is investigated and, in the wave interval from $\lambda/2 = 285$ mm. to $\lambda 2 = 440$ mm., a selective absorption is found for all the alcohols with which experiments were made. A. E. G.

1206. *Sparks Extinguished by Gaseous Blasts.* **J. L. Breton.** (Comptes Rendus, 176. pp. 471–473, Feb. 19, 1923.)—In the generation of high-frequency oscillations by means of sparks, it is well known that the performance is improved by placing the spark-gap in a blast of air, and also by causing the spark to take place in an atmosphere of hydrogen, coal-gas, etc. The author describes a type of generator embodying both these principles; the spark takes place in an atmosphere of hydrogen, which is rapidly circulated so as to constitute an extinguishing blast. At first the circulation was obtained in a closed vessel by means of a special compressor, but the improvement in efficiency obtained was hardly sufficient to justify the very considerable complication of apparatus. A later form, however, employing as one of the electrodes a disc rotating at a speed of from 3000 to 4000 r.p.m. in a chamber hermetically sealed and containing the gas, does not suffer from this disadvantage. Water cooling enables continuous operation over long periods. Curves are given of the watts per ampere necessary to produce various high-frequency currents in three cases: (1) A mercury interruptor working in alcohol, (2) the spark-gap with specially rotated gas, (3) the spark-gap with the rotating disc in a gas. It is seen that for small values of the h.f. current the order of efficiencies is 1, 3, 2; but at high values it is 2, 3, 1. E. M.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1207. *A Photoelectric Effect in Audion Bulbs of the Oxide-Coated Filament Type.* **T. W. Case.** (Am. Electrochem. Soc., Trans. 39. pp. 423–428; Disc., 428, 1921.)—Records the discovery of photoelectric effects from certain oxide-coated filaments of some high-vacuum Western Electric audion bulbs. Calcium, barium, and strontium oxide cells were made, but the two latter were principally used. The photoelectric current is proportional to the light intensity. The current for average sunlight is 100 to 150 micro-amperes. This is sufficient to run recording ammeters, and thus furnish a curve of daylight intensity. AUTHOR.

1208. *Hall Effect and Specific Resistance of Metal Films.* **J. C. Steinberg.** (Phys. Rev. 21. pp. 22–29, Jan., 1923.)—Work done by Wait on films of silver deposited chemically [see Abstract 209 (1923)] is extended to films of silver, copper, and iron obtained by evaporation in a vacuum. The films were deposited on a microscope slide by drawing an electrically heated filament to and fro over the slide, in a vacuum of 0·001 mm. of mercury, at a distance less than the mean free path. Details of the method are given. Values were found for the Hall coefficient and the specific resistance of films with thicknesses from 20 to 200 $\mu\mu$. The Hall coefficients of silver and copper films were respectively 41 and 11 per cent. less than the bulk values, but that of iron was increased by about 500 per cent. The specific resistances were from 15 to 57 times the values for the solid metals. The Hall effect is proportional to the field intensity in silver and copper, but this holds for iron only up to 10,000 gauss, indicating that the maximum intensity of magnetisation in iron films is only half as great as in solid iron. X-ray analysis by a method described by Hull [Abstract 380 (1918)] showed that films of silver and iron have the same crystal structure as the bulk metals. In these films the crystal grains are much smaller than in the solid materials, and this affects the physical properties of the metals. G. E. A.

1209. *An Application of the Electron Theory to the Hall Effect.* **J. A. Eldridge.** (Phys. Rev. 21. pp. 131–142, Feb., 1923.)—It is generally supposed that the simple electron theory of conduction leads to a negative coefficient for this effect and that the positive coefficients found for many metals are anomalous. But if we suppose the free path instead of the free time of motion of the electrons to be independent of the velocity, then in the *case of istropic conductors*, the effect comes out zero. Considering the group of electrons having a given speed immediately after collision with molecules, those moving with the electric field E will be retarded and will be more deflected by a magnetic field H than those moving against E, giving a positive coefficient, but electrons moving at right angles to both E and H will give a negative coefficient, and assuming all directions equally probable, the resultant effect for each group, and therefore for all, is found to be zero. By slight modification of the assumptions of the simple theory, either positive or negative coefficients may be obtained. The effect in crystals and a modified electron theory of conductivity are discussed. AUTHOR.

1210. *Theory of the Hall Effect and Related Effects for Several Metals.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 9. pp. 41–46, Feb., 1923.)—A theory is sketched which relates the Hall effect, R, with the Ettingshausen (P), Nernst (Q), and Leduc (S) effects. Two transverse streams of electrons are supposed to exist in the metal plate; one of these consists of free electrons which would of themselves set up a negative Hall coefficient R_f, and the other consists of associated electrons with positive coefficient R_a. The two effects would not in general be equal. The value of R_f is given by $-(6\cdot 28d'x) \div kT^{0\cdot 5}$, where $x = l_0\nu^{1/3}$, and l_0 is the mean path of the free electrons at 0° C. and ν is the number of atoms per c.cm.; $d'x$ is the length of the mean free path at temperature T, and k is the specific conductivity of the metal and equal to $k_a + k_f$. R_a is found from $R = R_a k_a/k + R_f k_f/k$. R_f and R_a are compared with the e.m.f.'s of two cells in opposition. The Ettingshausen effect is explained as a heating effect at one side of the plate caused by the combination of free electrons with ions, and a cooling effect at the other side caused by ionisation. The condition of equilibrium between the two effects is expressed by the equation $P\theta = (R - R_f)k_f\lambda$, where θ is the thermal conductivity of the plate and λ is the number of calories required to free $1/e$ electrons. Values found for x range from 4 to 40 for the seven metals Cu, Au, Ag, Al, Ni, Pd, and Pt. The author has worked out a relation between the Hall and Nernst effects, and one relating the Leduc and Nernst effects. A table is given of the values of P, Q, R, and S for the above metals, found by Unwin, Little, and others. G. E. A.

1211. *Variation with Temperature of the Dielectric Constants of Benzene, Acetone, and Glycerine.* **W. Graffunder.** (Ann. d. Physik, 70. 3. pp. 225–249, Feb. 15, 1923.)—A method for determining the values of the dielectric constants of substances of various temperatures, correct to 0·005, by means of electrical oscillations between coupled circuits is briefly described. In the case of benzene, determinations were made between 5° C. and 80° C., while in the cases of acetone and glycerine, values of the dielectric constants were made at temperatures between − 32·9° C. and 54·0° C., and − 32° C. and 99·2° C. respectively. For liquid benzene, the results are in agreement with the values found by Isnardi, except that the sudden rise in the value of the dielectric constant observed by the latter as the temperature fell just above the melting-point was not observed in the case of the present experiments. No evidence of the existence of dipoles in benzene was obtained. The results for acetone were of the same general nature as those obtained in the case of benzene, a fall of temperature producing a linear increase in the value of the dielectric constant. The function $(\epsilon - 1)T/(\epsilon + 2)d$ is not, as required by Debye's theory, a linear function of the temperature. No evidence of the existence of dipoles in the liquid is obtained by interpreting the results by means of Debye's theory or that developed by Gans and Isnardi. The apparent existence of dipoles is attributable to molecular association occurring in the liquid. In the case of glycerine, the value of the dielectric constant increases rapidly with increase of temperature from $-32°$ C. to about $+14°$ C., and thereafter decreases more slowly with increasing temperature. The results do not afford evidence of the existence of dipoles in glycerine, but these very probably do occur, their existence being indicated by the occurrence of anomalous dispersion in the liquid. The results support the Clausius-Mosotti rule of the constancy of the expression $(\epsilon - 1)/(\epsilon + 2)d$, the respective variations of this expression in the case of benzene, acetone, and glycerine respectively amounting to 1·40 %, 7·2 %, and 1·78 %, these being smaller than the deviations shown by the expressions $(\epsilon - 1)/d$ and $(\sqrt{\epsilon} - 1)/d$. [See Abstract 746 (1920).] J. S. G. T.

1212. *Measurement of the Capacity of a Thin Wire Coil having a Large Number of Windings, and the Dependence of the Factor in the Thomson Equation on the Magnitude of the Additional Capacity.* **E. Marx** and **A. Karolus.** (Phys. Zeits. 24. pp. 67–70, Feb. 1, 1923.)—For purposes of measuring the resistances of coils possessing great self-induction, the usual processes involving bridge arrangements are inapplicable, and an oscillation method has to be adopted. This not only demands special precautions, but is dependent on the availability of the Thomson formula $t = 2\pi\sqrt{LC}$. The method now described gets over both types of complication, and very full apparatus details with illustrative diagrams are included. The principles of the arrangements employed are as follows: (1) A primary coil is coupled so loose with that to be measured that the oscillation frequency of the latter is not appreciably influenced. (2) By change of frequency of the current, the tension in the primary coil is kept constant and the maximum tension in the other coil evaluated. (3) Different supplementary capacities are employed in conjunction with the unknown. (4) The tension measurement at the primary and secondary coils is found by means of a high ohm valve-voltmeter arrangement using a highly sensitive mirror galvanometer. The frequency measurement is made acoustically. Tables of data are given. H. H. Ho.

1213. *Actuation of Spark Coils by Condenser Discharges.* **J. Härdén.** (Zeits. techn. Physik, 4. 3. pp. 127–128, 1923.)—Starke [Abstract 2017 (1922)] has described a method for operating spark coils by means of condenser discharges. Similar methods have been used by the present author for several years. In the first apparatus used a small coil (whose normal spark length with a hammer break was about 12 mm.) was connected with five 2-μfd. condensers which were charged by means of a rotating interrupter from a 200-volt d.c. supply. In this way the spark length was increased to about 22 mm., and the spark was stronger and brighter than before. A larger apparatus made use of a coil of 7·5 cm. (normal) spark length, with which 100 2-μfd. condensers were connected, a rotating interrupter with blades dipping into mercury being used. Very strong and regular sparks were obtained with this apparatus, using 220-volt d.c. supply. The application of the method to sets of higher power is briefly discussed. A. W.

1214. *On the Measurement of the Coefficients of Self-Induction at High Frequency.* **V. Ylostalo.** (Comptes Rendus, 176. pp. 576–578, Feb. 26, 1923.)—The coefficient of self-induction at high frequency of a coil cannot be calculated with accuracy. It is modified by the pellicular effect, *i.e.* by the localisation of the current in those parts of the wire nearest the axis of the coil [see Abstract 457 (1910)]. On the other hand, the capacity of the coil itself produces an apparent increase of its own induction. These effects are much less pronounced when the frequency is low, but when this approaches the resonance frequency of the coil, the current no longer preserves a constant intensity throughout the coil and so produces a consequent modification of the self-induction. The present investigation concerns the self-induction of coils of different forms using the frequencies of radio-telegraphy, with the object of deducing the limits of application of the Thomson formula and so enabling the wave-lengths of the oscillating-currents to be calculated. It is then demonstrated that the electrometer employed by Bjerknes for the study of the Hertz resonator furnishes with ease of application exact measurements at high frequency. Experimental details are fully described with abundant data. H. H. Ho.

1215. *Measurements on Electrostatic Relays* (*Johnsen-Rahbek*). **L. Bergmann.** (Zeits. techn. Physik, 4. 1. pp. 11–14, 1923.)—The author describes experiments on a phenomenon observed by Johnsen-Rahbek that when a conducting plate is laid on a partial conductor and the system traversed by an electric current there exists between the plates a force of electrostatic attraction. To measure this effect a brass plate about 20 sq. cm. in area is suspended from one arm of a balance, its underside being in contact with a plate of the material to be investigated. A sheet of Al foil is cemented to the lower surface of the material, and the circuit through the plates completed through a battery, galvanometer, and resistance. When the current is passed the balance is gradually loaded until the brass plate separates from the material. The results are not consistent for the same material and the same applied potential, varying with the condition of the surfaces and the way in which they are brought into contact. A table of average values is given in the paper. The following data from this table show the average order of the effect:

Substance.	Load in gm. to Separate Plates for Applied Potential.			Current Passing.	Potential of Brass Plate on Separation.	Surface.
	100 v.	150 v.	200 v.			
Agate	203	253	355	$3·1 \times 10^{-6}$ amp.	1670 v.	polished
Pure gypsum ..	36	65	77	$14·4 \times 10^{-6}$	$<$ 500 v.	polished
Galalith (white)	48	142	227	$1·4 \times 10^{-8}$	3570 v.	smooth
Galalith (black)	55	175	325	$3·6 \times 10^{-8}$	3220 v.	smooth
Mirror glass ..	0	0	0	0	1600 v.	polished

By attaching the brass plate to the lower end of an ebonite tube along whose axis a metal contact rod could be moved it was possible to raise the plate at the instant the current was broken and measure its potential with an electrometer. L. L.

1216. *Application of the Plane-Cylinder Electrometer to the Determination of the Inductive Powers of Solid Bodies.* **L. Bouchet.** (Comptes

Rendus, 176. pp. 377–380, Feb. 5, 1923.)—In a previous paper the author has investigated the case of a cylinder attracted by a plane, the conductors being separated by air [Abstract 554 (1923)]. This apparatus has now been adapted for the determination of the inductive powers of solid insulators, *e.g.* glass, rubber, and paraffin. The attractions have been determined as functions of the potential differences between the two conductors separated by the insulators in question. The inductive powers have then been evaluated, the data obtained being in good agreement with corresponding data by other physicists, *e.g.* 7·8 for glass (Curie, 7·6), and 2·3 for paraffin (Malclès and Floquet, 2·3). Rubber was found to possess greatly varying values according to the admixed substance, *e.g.* rubber and sulphur, 2·6; rubber, sulphur, and litharge, 11.
H. H. Ho.

1217. *Corona Voltmeter.* **J. R. Clarke.** (Röntgen Soc., J. 19. pp. 27–32, Jan., 1923.)—Corona occurs at a lower voltage when the wire is negative than when it is positive. If F be the voltage gradient at the surface of a wire of radius a, then $F = A\vartheta\,(1 + B/\sqrt{\vartheta a})$, where A and B are constants and ϑ the density of the gas in which the discharge takes place. If the wire be surrounded by a co-axial cylinder of radius b, then the voltage gradient at a point distance r from the common axis is $E/(r \log_e b/a)$, so that corona will occur when

$$E = a \log_e b/a \left[A\vartheta\left(1 + \frac{B}{\sqrt{\vartheta a}}\right)\right].$$

By suitably choosing a and b, the discharge can be limited to corona, sparking being prevented. It is found that rods or tubes are preferable to wires, as the diameter may be considerable. Two methods can be employed for measuring corona voltage. The first, which is rather expensive, is to mount cylinder and rod in an air-tight case. The rod is connected to one terminal of a high-voltage generator, and the cylinder to the other, and the pressure (and so the density of the density of the air) is adjusted till corona just starts. The second method is to mount cylinder and rod in air, rods of varying radii being employed for the different voltages, the current being adjusted through the primary of the high-voltage generator, so that corona always just forms. The voltmeter connections are shown diagrammatically.
T. C. H.

1218. *New Type of Oscilloscope.* **F. L. Hopwood.** (Röntgen Soc., J. 19. pp. 33–34, Jan., 1923.)—This instrument, called an "Ondoscope" by the author, is an oscilloscope so mounted that it can be rotated about an axis parallel to the tube and thus used for obtaining the "current-time" curve of a high-tension discharge apparatus; and, if the applied voltage exceeds the ionising voltage of the oscilloscope tube, is suitable for any alternating or fluctuating current. It can be used on circuits from 200 volts up to 250,000 volts or more, and will give the current wave-form when the current has a maximum value between 2 milliamperes and 50 or more.
T. C. H.

1219. *Direct-Reading Thermionic Voltmeter and its Applications.* **E. B. Moullin.** (Inst. El. Eng., J. 61. pp. 295–303; Disc., 304–307, Feb., 1923.)—The conditions suitable for constructing a sensitive direct-reading voltmeter from a triode rectifier are discussed and two distinct forms of completed thermionic voltmeter are described [see also Abstracts 856B (1922) and Abstract 57B (1923)]. The power absorbed by a rectifier is discussed theoretically and a description is given of the experimental methods of measuring the effective resistances of a thermionic voltmeter. Possible causes of frequency errors in the calibration of the voltmeter are considered and the results of experiments are quoted, showing that a calibration made at low frequencies is reliable up to at least one million periods per second. Several typical illustrations are given of the uses of the voltmeter in measurements at both high and low frequencies. In his reply to the *discussion*, the author points out that each instrument has to be calibrated with its own particular valve—but different valves by the same manufacturer seem to repeat themselves within 5 %. It is possible also that the calibration may change over long periods of time. A. B. W.

1220. *Vibration Galvanometers with Asymmetric Moving Systems.* **R. L. Jones.** (Phys. Soc., Proc. 35. pp. 67–80, Feb., 1923.)—In the theory of the vibration galvanometer with one degree of freedom, certain specified conditions are assumed to hold, *viz.* that the axis of suspension is rigid and does not yield to forces tending to produce lateral displacements, or, that the axis, if not rigid, passes through the centre of mass of the moving system and is a principal axis at that point. If these conditions are not satisfied in a galvanometer, the instrument will show multiple resonance, a circumstance indicating the need for a more general theory. Accordingly the theory of vibrations of a system with two degrees of freedom is briefly given, expressions for the amplitudes of the forced vibrations are deduced, and the conditions for resonance ascertained. The results are then applied to a galvanometer in which the moving system is asymmetrically hung on a laterally yielding axis, and it is shown that the formula for the amplitude is capable of reproducing with fair accuracy the sensitivity curve of the galvanometer exhibiting multiple resonance. Asymmetry always lowers the sensitivity of the resonance, and the loss can be ascertained by the help of the sensitivity curve. The analogy to the vibrations in coupled circuits is pointed out. Reference is made at the close to work by Kennelly and Taylor on properties of vibrating telephone diaphragms in which phenomena are described analogous to those in the vibration galvanometer, while the theory is presented in a different form to that adopted in the present paper. H. H. Ho.

1221. *The Kathode Ray Oscillograph.* **A. B. Wood.** (Phys. Soc., Proc. 35. pp. 109–123; Disc., 123–124, Feb., 1923. Chem. News, 126. p. 12; Disc., 12–13, Jan. 5, 1923. Abstract).—A description is given of a new form of kathode-ray oscillograph which is of a low-voltage type in which a hot kathode is used as the source of electron current and is designed in a simple and robust form. The main bulb carrying the heated kathode, drying bulbs, and a pair of side tubes to support the electrodes of the deflecting plates are made of glass, but the remainder of the apparatus is made of brass. The various parts are easily assembled or taken apart and rendered air-tight by means of accurately fitting greased conical joints or flanges. An X-ray vacuum is obtained within about 10 min. by the Gaede pump.

The kathode consists of a filament of either tungsten or lime-coated platinum, preferably of a flat spiral form. The rays are directed on to a pinhole tube which is connected as anode and allows a narrow beam to emerge and, after passing between parallel electrostatic and electromagnetic plates, to impinge on a phosphorescent screen or photographic plate at the base of the apparatus. A p.d. of about 3000 volts is applied between the filament and the anode to accelerate the rays. With voltages below 1000 the beam is not sufficiently intense to give a marked photographic effect. The low voltage used renders the instrument considerably more sensitive than the Dufour oscillograph which employs 60,000 volts. Various devices which have been investigated for increasing the intensity of the beam of rays by focusing include the use of concave kathodes, surrounding the filament with a cylindrical sheath and the application of electromagnetic fields. For the photographic records the maximum sensitiveness is obtained by the use of Schumann plates containing a proportion of calcium tungstate which phosphoresces with a light rich in ultra-violet and consequently gives a powerful secondary luminous effect.

Mechanical, electrostatic, and electromagnetic methods are described for generating a time axis on the records. For certain purposes this time axis is sinusoidal and for others it is rectilinear. Reference is made to applications of this oscillograph to measurements where other types cannot be employed on account of the inertia of the moving element.

J. N. P.

1222. *Apparatus for Determining the Magnetic Properties of Short Bars.* **M. F. Fischer.** (Bureau of Standards, Sci. Papers, No. 458. pp. 513–526, 1922.)—Apparatus and method are described by means of which 10-cm. bars may be magnetically tested. A reference bar is obtained, the properties of which are determined by the ordinary methods. This standard bar and the test bar are then placed in a "comparator," *i.e.* an electromagnet the pole-pieces of which are joined by the two bars. Test coils are wound on the bars and connected to a ballistic galvanometer; the indications from the standard bar furnish data for the magnetising forces, and those from the sample bar give the corresponding inductions. Calibration curves and results given by the method are shown. The errors need not exceed 5 % of the magnetising force for a given induction.

G. E. A.

1223. *New Form of Magnetic Balance.* **W. P. Conly.** (Inst. El. Eng., J. 61. pp. 161–166, Jan., 1923.)—The balance consists of a long beam of ash with a rigid coil depending from one end. The plane of the coil coincides with the plane of motion of the beam, and the coil has two long sides which are arcs of concentric circles with centre on the knife edge. The short sides are radial and 1 cm. long. The coil contains ten turns, and when it carries 1 ampere the force on the lower side when in unit field is 1 dyne. The beam arms are of such lengths that this force is balanced by a weight of ·1 mgm., and for any field the intensity is measured by the number of mgms. required to bring the beam to zero. The use of the instrument is exemplified by testing the distribution of the field along the side and edge of a bar magnet. The surface of the magnet is not an equipotential surface. The apparatus can also be employed to verify Biot-Savart's (Laplace's) law.

G. E. A.

ALTERNATING CURRENTS AND MAGNETISM.

1224. *Some Inequalities Important in Electrotechnics.* **L. Bouthillon.** (Rev. Gén. d'El. 12. pp. 925–927, Dec. 16, 1922.)—A mathematical paper, relating particularly to oscillations in electric circuits. W. R. C.

1225. *Stationary Waves on Open-Ended Solenoids.* **A. Press.** (Inst. El. Eng., J. 61. pp. 405–406, March, 1923.)—A mathematical investigation in which the inductance and capacity per unit length at distance x from the centre of the coil are assumed to be of the form $L_x = L/\phi(x)$, $C_x = C/\phi(x)$, where $\phi(x)$ is an arbitrary function depending on the geometry of the coil alone. Differential equations for the potential and current distribution along the coil are found, the solutions of which indicate that the nodal distances progressively diminish towards the ends of the coil. E. M.

1226. *Theories of Magnetism.* **A. E. Oxley.** (Nature, 111. pp. 54–56, Jan. 13, 1923.)—The author traces the development of magnetic theory from that of Poisson, published in 1820, to the present day. He considers that the theory that the electron is also a magnetic doublet or magneton can be adapted to the Lewis-Langmuir theory of the cubical atom; in "non-ionised" media the coupling force between atoms is due to pairs of these magnetons (electrons), each pair corresponding to a single valency bond. In metallic salts, which are formed by the union of positive and negative ions, the coupling between the atoms is probably due to electrostatic forces. It does not appear obvious how the Bohr-Sommerfeld theory can explain diamagnetism, or the directed forces which hold crystal lattices together. It seems as if the atom must have a static structure; but Whittaker's recent theory as modified by H. S. Allen gives a structure which is dynamical locally, but is essentially static at ranges comparable with molecular dimensions; it also gives an explanation of the quantum relations between a colliding electron and the atom. Experiments on the occlusion of hydrogen by palladium, manganese and iron indicate that, in each case, an electronic system is produced corresponding to the element whose atomic number is one more than that of the occluding element; it is suggested that the H-electron enters the outer electron shell of the metallic atom, and so makes it resemble that of the metal standing next above it in the list. It is considered that these experiments can only be interpreted by means of a static model of the atom. H. N. A.

1227. *Magnetic Properties of Iron-Carbon Alloys as Affected by Heat Treatment.* **W. L. Cheney.** (Bureau of Standards, Sci. Papers, No. 463. pp. 609–635, 1923.)—A series of iron-carbon alloys with carbon content varying from 0·018 to 1·60 per cent. was subjected to two kinds of heat treatment; one group was first hardened by quenching from temperatures above the critical range and then drawn back to successively higher temperatures; another set was annealed *in vacuo.* After each heat treatment, magnetisation curves and hysteresis data were taken, and in most cases the magnetic property is graphed with the drawing temperature. The hardened alloys when drawn back to successively higher temperatures showed marked changes in the normal induction, residual induction, and coercive force which correspond to transformations of the material. The annealed specimens were measured by a method dealt with in another paper [see Abstract 1222 (1923)]. The magnetic tests indicate three distinct ranges: up to drawing-temperature 230° C.; from 250° to 450°; and from 470° to 700°, in which the constituents differ in their magnetic characteristics. The experiments bring out the marked sensitiveness of magnetic quantities to any slight changes of metallographic structure, and the necessity for very accurate control of heat treatment when magnetic properties are under investigation. G. E. A.

1228. *The Magnetic Change A_2 in Silicon and Chromium Steels* **H. Scott.** (Chem. and Met. Eng. 28. pp. 212–215, Jan. 31, 1923.)—The change point is continuous, reaching a maximum rate of change at 768° C. in the case of pure iron and carbon steels. When silicon and chromium steels are considered, modifications in the change are found, which may render inapplicable the magnetic method for determination of hardening temperatures. Ac_1 is raised 21° C. and Ar_1 18° C. for each per cent. silicon added up to at least 3 %. Ac_2 is lowered 21° C. for the same increment. Chromium raises Ac_1 11° C., and Ar_1 6° C. for each 1 % addition up to about 7 %, above which they are stationary. But Ac_2 is only lowered in the higher percentages. Ac_2 occurs below Ac_1 for silicon steels above 1·2 % and chromium steels above 2·5 %. When Ac_2 occurs below Ac_1 the latter change is not detectable by the usual magnetic methods. [See Abstract 1479 (1915).] J. L. H.

1229. *The Physics of Hysteresis Loss.* **A. Press.** (El. World, 81. pp. 213–214, Jan. 27, 1923.)—The paper has been written to direct attention to the importance of the Heaviside formula in bringing about coordination in the essentials of the subject of hysteresis. Many of the difficulties which Whitehead collected in his letter to the Electrical World of Nov. 11, 1922, are stated by the present author to be explained if note is taken of some recent work in which no less than two mechanical models of hysteresis have been evolved [see Abstract 2 (1923)]. One of these is described and utilised in the discussion. Neglect of the Heaviside formula has led to loss of proper emphasis, and it is remarked that in the ether itself there can be neither magnetic nor electric hysteresis proper, but such hysteretic phenomena as may be present at all, whether viscous or static, must be a property of matter and not the ether, and as the author shows explicable by means of the model. H. H. Ho.

1230. *The Gyromagnetic Effect.* **O. W. Richardson.** (Roy. Soc., Proc. 102. pp. 538–540, Feb. 1, 1923.)—Chattock and Bates have shown the gyromagnetic ratio for ferro-magnetic substances to be nearly equal to m/e instead of $2m/e$ as indicated by theory if rings of electrons only are involved. This can be explained by assuming certain constitutional properties of the electron, but a more satisfactory theory takes account of the positive charges of the atom. The saturation intensity of iron is within a few per cent. of twice the fundamental quantum unit, $h/2\pi$. Hence the ferro-magnetism of iron is probably due to a pair of parallel or coplanar electron orbits, each with a single azimuthal quantum. If the positive nucleus is allotted another quantum and turns in a similar sense to the electrons, its magnetic moment will be opposed to that of the electron orbits and the total gyromagnetic ratio will be given by: $\frac{m}{e}\Big/\left(1-\frac{1}{2}\frac{E}{e}\frac{m}{M}\right)$ where capital letters refer to positive and small letters electron charges. For iron $E = -26e$ and $M = 56 \times 1835m$, and the gyromagnetic ratio is given by m/e to about 1 part in 10,000. Other quantum conditions can be made to explain the effect, but this seems the most probable. A. Wh.

1231. *Magneton Number of an Atom in Solution.* **J. H. Smith.** (Phil. Mag. 45. pp. 375–378, Feb., 1923.)—The magnetic moment per gramme-molecule can be calculated from the susceptibility, and the magnetic moment per gramme-atom for the metal found by subtracting the diamagnetic moment per gramme-acid radicle. The measurement of the susceptibility of cobalt chloride were made with an apparatus similar to that used by Pascal [see Abstract 993 (1910)]. The volume susceptibility of cobalt chloride is about 2 per cent. less in alcohol solutions than in water solutions of the same strength. The magneton number for cobalt as found by Weiss's method is 24·6, which agrees with 24·5 found by Miss Brant. G. E. A.

1232. *Comparison of Sun-Spot Areas and Terrestrial Magnetic Horizontal Force Ranges* 1911–1921. **B. G. Swindells.** (Roy. Astron. Soc., M.N. 83. pp. 215–217, Jan., 1923.)—Stonyhurst data are used in the comparison which is made by means of a set of four smoothed curves, based on monthly means, showing, with time as abscissa, the variation throughout the eleven years of (*a*) sun-spot mean daily areas; (*b*) horizontal force, mean daily range, quiet days; (*c*) ditto, all days; (*d*) ditto, all days minus quiet days. The general features to which attention is drawn are that (*b*) shows a very regular annual period, and also the 11-year period indicated by a regular rise and fall of the annual maxima and minima; (*c*) follows the form of (*b*) from 1912 to 1917 (the year of sun-spot maximum), when it reaches its highest point, after which it becomes irregular until 1920 inclusive; these features are reflected in (*d*) which, however, does not reach its highest point until 1919. Further (*a*) shows some remarkable coincidences with (*d*), but it appears that, though the maxima coincided in 1917, the max. magnetic disturbances preceded the corresponding maxima of solar disturbance in 1915 and 1916 and followed in 1918, 1919, and 1920, coincidence again being reached in 1921. The magnetic curve (*d*) also shows an outstanding decrease in 1915 almost coinciding with a rise to a secondary max. of solar disturbances. M. A. G.

1233. *History of the Compass.* **E. Wiedemann.** (Zeits. f. Physik, 13. 1 and 2. pp. 113–116, 1923.)

1234. *Magnetic Measurements in Brittany.* **C. Maurain.** (Comptes Rendus, 176. pp. 847–850, March 19, 1923.)

1235. *The Wave-Form of Duplex Coils for Deep Therapy.* **M. A. Codd.** (Röntgen Soc., J. 18. pp. 183–186, Oct., 1922.)—The author describes experiments carried out upon his deep-therapy apparatus to ascertain the correctness of the statements that: (*a*) An abnormally large primary condenser is required to annul oscillations in the secondary circuit, (*b*) that these oscillations are necessarily harmful from both the therapeutic point of view and of injury to the tube, and (*c*) that a large gap in the neutral point in the secondary is necessary in order to ensure that the tube shall give out hard rays only. Experiments with the author's duplex coil are described and the results summarised as follows: (1) The use of a large capacity is needless in that it does not affect the output, and would tend to give oscillations in the tube were it not for the smallness of the current flowing. If obtainable in higher magnitude, these oscillations would, however, be useful. (2) A large spark-gap in the secondary circuit is undesirable, particularly when placed in the neutral point. Relatively small rectifying ball-gaps, having a certain capacity and placed between the secondaries and the tube, are more effective. (3) A slow rate of interruption is, within limits, probably better from a therapeutic point of view than a very fast rate of interruption, but rates up to 100 per second can be used. B. J. L.

1236. *Annual Report of the Director of the Department of Terrestrial Magnetism.* **L. A. Bauer.** (Carnegie Inst. of Washington Year Book, No. 21. pp. 266–309, 1922. Extract.)

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1237. *Radiography and Physics.* **G. W. C. Kaye.** (Nature, 111. pp. 364–366, March 17, 1923. Abstract of opening address to the Society of Radiographers, Oct., 1922.)

1238. *The Röntgen Institute of the Surgical Clinic of Würzberg University.* **F. A. Buchholtz.** (Elekt. Zeits 44. pp. 209–210, March 8, 1923.)—Gives a general description of a large Siemens and Halske (Multivolt) deep-therapy installation. This apparatus gives a secondary voltage of 220 kv. and represents the latest developments in this class of work. Illustrations are given of the apparatus room, the control room, and the treatment room. In the latter all the high-tension connections and the tubes are enclosed in a large lead chamber of 8 mm. thickness except for the radiation aperture. Hence there is very complete protection for patients and operatives. B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1239. *Velocity of Formation of Precipitates.* **R. G. Boussu.** (Comptes Rendus, 176. pp. 93–95, Jan. 8, 1923.)—A method for studying the rate of formation of precipitates was developed, which consisted in allowing the precipitate to form in a solution already saturated with the body to be studied. Into this "stop solution" is run a jet of two solutions, one already precipitated and one supersaturated. When they are mixed, the precipitate is rapidly filtered off and weighed. So long as the ratio of volume of precipitating liquid/volume of stop solution is small, the precipitation can be stopped at any required point. The precipitation of calcium as oxalate from solutions of nitrate of calcium and oxalic acid was studied, and it is proposed to use it in the case of sulphate of calcium and potassium bitartrate. F. J. B.

1240. *Repetition Experiments Concerning the Rubbing of the Walls of a Vessel with a Glass Rod to Induce Crystallisation.* **R. Fricke.** (Zeits. Elektrochem. 29. pp. 44–46, Jan. 1, 1923.)—The author has carried out the experiments now described as a reply to Dede's polemic [see Abstract 977 (1923)]. The fact of crystallisation being produced in a solution by scratching the walls of the containing vessel, lends considerable support to the view that removal of the surface layer is the cause of such separation, and the author states the phenomenon to occur much better with potassium bitartrate solution than with magnesium ammonium phosphate. By using a solution saturated with CO_2, the course of the scratch can be followed by a path of CO_2 bubbles, and this obtains whether glass, rubber, wood, iron, nickel, or other scratching agent be employed. In consequence, the author opines it not excluded that a fine glass suspension arising from glass friction may operate favourably by this generation of new surface. Experiments are now described to settle this question, using solutions containing sodium bitartrate and KCl. Violent shaking is found not to promote crystallisation, neither does a previously prepared glass suspension, nor the introduction of a glass rod which has been electrified by rubbing with leather. Crystallisation, however, immediately commences when a glass tube is held immersed in the liquid and scratched by means of tongs. This experiment was repeated for various concentrations of the solution and also for varying amounts of KCl. The glass particles so produced do not occasion turbidity, but fall to the floor of the vessel. The fresh surface generated and so deprived of the liquid layer for a short period appears to be the potent factor. The author was unable to obtain all Dede's results, but ascribes his failures possibly to variations of conditions. H. H. Ho.

1241. *Behaviour of Ferric Hydrate in Presence of Water.* **S. Veil.** (Comptes Rendus, 176. pp. 101–103, Jan. 8, 1923.)—Ferric hydrate has a composition which varies with the temperature of precipitation, becoming dehydrated in the presence of water. It was found by means of magnetic measurements that two distinct phenomena are produced, dehydration and a modification of the ferric hydroxide, so that the coefficient of activity of the oxide after final dehydration varies between 1 and 30. When ferric hydrate is precipitated from ferric chloride in the cold, filtered and washed as rapidly as possible, and the hydrate calcined, the oxide has a coefficient of activity of 1. The hydroxide itself has a coefficient of activity of 9·8. If this same hydroxide is heated in a sealed tube to 120° C. for 12 hours, it is almost completely dehydrated. Its coefficient of activity is 4·8, and that of the oxide obtained by calcination is 4·6. When the oxide is dissolved in hydrochloric acid, by aid of heat, and precipitated immediately after solution, the value of the coefficient of activity is the same as that obtained in the cold. If this hydroxide is heated in a sealed tube, the coefficient of activity rises to 28·5, and that of the resulting oxide calcined at 600°, to 24·1. Similar results were obtained, with hydroxide and oxide formed from the nitrate. F. J. B.

1242. *Electrochemical Aspects of Photographic Development.* **S. E. Sheppard.** (Am. Electrochem. Soc., Trans. 39. pp. 429–440, 1921.)—Discusses previous work and adds information being developed at the research laboratory of the Eastman Kodak Company. Discusses the physical chemistry of the development reactions, and points out the present unsatisfactory value of the measurements by electrical methods, which are entirely relative to the particular experimental conditions. AUTHOR.

1243. *Berthelot's Normal Acids and Theory of Ions.* **F. Bourion.** (Comptes Rendus, 176. pp. 95–98, Jan. 8, 1923.)—The Berthelot definition of normal acids, *i.e.* those which evolve 12–16 large calories, when 1 equivalent of acid and 1 equivalent of base in 2 litres are mixed, is discussed. The cases of no appreciable hydrolysis and a small amount of hydrolysis, are examined, and the differences in heats of neutralisation calculated. F. J. B.

1244. *Bibliography of Scientific Literature Relating to Helium.* (Bureau of Standards, Circ. No. 81. [32 pp.] Washington, 1923.)

1245. *Thermal Effect of Vapours on Rubber.* **A. S. Houghton.** (Phys. Soc., Proc. 35. pp. 39–43; Disc., 43–44, Dec., 1922.)—This paper relates to the heating of rubber when suddenly immersed in various vapours. Measurements are made by coating alternate thermo-electric junctions with a thin film of rubber, plunging the junctions into the vapour and noting the heating effect, using a galvanometer. The results obtained with ether, benzene, pyridine, ammonia, water-vapour, and dry air are given. When the rubber is immersed in the vapour a sudden heating occurs followed by a gradual return to normal as the rubber becomes saturated with vapour. On withdrawing the rubber, a sudden cooling occurs followed by a gradual return to normal as the vapour evaporates. With dry air a cooling effect is noticed on immersion and a heating effect on withdrawal. The effect is compared with that of water-vapour on cellulose where the heating of the cellulose is attributed to the liberation of the heat of condensation when the water-vapour condenses on the fibres. In the case of rubber it is probable that only part of the heat is produced by condensation of the vapour and that the additional heat is supplied either by some form of chemical union or by the formation of a solid solution between vapour and rubber. The experimental facts prove the existence of this second phase. T. H.

1246. *Anomalous Osmosis with Colloidal Membranes.* (1) *Electrical Properties of the Membrane System.* **F. E. Bartell and D. C. Carpenter.** (J. Phys. Chem. 27. pp. 101–116, Feb., 1923.)—Membranes were prepared by pouring a solution of collodion over a clean mercury surface. The solution was prepared by diluting 100 c.c. of a solution of 3 % soluble gun-cotton in 75 % ether and 25 % absolute alcohol, with an equal volume of the solvent, and allowing the solvent to evaporate slowly. At 25° C. four hours were required for drying so as to produce a membrane of medium permeability. A shorter drying period produced more permeable, and a longer drying period or higher temperatures less permeable, membranes. The membranes were then fitted between two glass **T** tubes of 15 mm. diameter, held together by a brass clamp. The pressures were measured by the rise of the liquid in calibrated tubes. The osmose values were obtained for thirteen different salts, an acid, and a base, selected to show the relative influence of kation and anion valence, hydrolysis of salt, weak and strong acid radical, at concentrations 0·001, 0·01, 0·1, and 1·0 molecular normal. The maximum potential with each of these osmotic systems was measured. The sign of the membrane charge has been determined by cataphoresis, using finely ground membrane materials in suspension.

Consideration of the data obtained shows that the initial osmose rate of practically all the salts examined bears a definite relationship to the electrical properties of the membrane system. The anomalous effects obtained with collodion are very similar to those obtained with membranes of porcelain, of goldbeater's skin, of calf's bladder, and of parchment paper, and allowing for the electrical orientations of the different membrane systems, the results are very closely comparable.

It was shown that anomalous effects are related somewhat to the time factor. For example, the data for the osmose of potassium carbonate at the end of a two-hour period, when plotted against log (concentration of K_2CO_3) gave no N-shaped curve, while the N-shape was pronounced for the curve obtained at the end of a 12-hours osmose. This fact makes it appear probable that the process of diffusion is in some way responsible for the repressing effects noted. F. J. B.

1247. *Constitution of Colloidal Gels.* **M. J. Duclaux.** (Soc. Chim. de France, Bull. 33. pp. 36–43, Jan., 1923.)—The theory is put forward that an irreversible gel, as for instance, silica in water, consists of two phases in which one is a solid giving a sponge of ultramicroscopic cellular structure which is probably crystalline and contains the pure solvent. Such a material, when dry, has no tendency to re-form gel. A reversible gel is considered to contain in addition at least one other phase. This is described as plasma and consists of a solution of the solid in the liquid occluded by the solid phase, giving molecules or micelles which may be either crystalloid or colloid; and while too large to leave the network of solid, yet they exert an appreciable osmotic pressure towards the solvent. Swelling of the gel takes place on account of this osmotic pressure, and an equilibrium condition is reached when this osmotic pressure balances the cohesion of the gel sponge. Measurements have shown that a complete parallelism exists between the variations of the osmotic pressure of the soluble constituent of the plasma of gelatin gel which has been isolated and the swelling power of the gel. If the osmotic pressure of the plasma is sufficiently great the partitions are broken, and there results a solution of the gel in which the two components coexist.

In the case of nitrocellulose and caoutchouc, it is considered that the variations in viscosity given by different fractions after precipitation from solution indicates the existence of soluble, or reversible, and insoluble, or irreversible, constituents. Nitrocellulose prepared at high and low temperatures of nitration form respectively products of low and high gelatinising power, giving solutions of low and high viscosity which are attributed to variations in the soluble and insoluble constituents. A gel such as nitrocellulose is reversible in one solvent, such as alcohol-ether, but not in another solvent, such as water, according to whether it contains any soluble element which can form a plasma capable of exerting osmotic pressure. In the case of gum arabic the insoluble constituent is practically absent, so that gelatinisation is at a minimum. With gum tragacanth, on the contrary, the insoluble constituent predominates and gels are given without true solution. J. N. P.

1248. *A Spectroscopic Method of Studying the Formation of Complex Salts in Dilute Solutions.* **Y. Shibata, T. Inouye,** and **Y. Nakatsuka.** (Japanese J. of Chem. 1. 1. pp. 1–18, 1922.)—A number of methods are known for detecting the formation of complex salts occurring on mixing two or more simple salts in solutions more or less diluted; but these are useful only in those cases where a stable complex salt is formed in the solution. If the formation of a complex salt occurs in a very incomplete manner, various electrolytic methods would be especially unsuitable, inasmuch as the loose combination between the components having the so-called residual affinity might be broken by the electric energy. As to methods other than electrolytic, measurements are difficult for thermal and other effects in very dilute solutions, and colour change is not always a reliable criterion, it being not necessarily the result of complex salt formation. In studying the absorption spectra of various colourless complex salts in the ultra-violet region, Shibata has found that the absorption spectrum produced by a complex salt always extends to the origin of longer wave-lengths than that produced by either of the component salts, and further the absorption ends are shifted more and more to the region of longer wave-lengths, as the number of components in a complex salt is increased. This property has now been utilised for studying the actual state of salts mixed in solution, the absorption spectrum of each mixture being photographed on a plate using the quartz spectrograph. The absorption spectrum of that mixture which contains the largest proportion of a complex salt is found to extend to the region of longest wave-lengths, and quantitative results can be based on such measurements. Experimental details are fully described, and it has been shown that out of nearly 60 pairs of salts, of which mercuric salt is one of the components, more than one-half give rise to the formation of a complex salt. Other pairs of salts, of which mercuric salt does not constitute one of the components, have, as a rule, not been found to form any complex salt. In this category, the case of $NiCl_2$-$CoCl_2$ has been made the subject of a special study, and it has been shown that the decolorisation which occurs on mixing the two salts in a suitable proportion arises merely from the complementary relation of the colours of the salts dissolved, and not from the formation of a colourless complex salt. None of the binary systems, containing ammonia or urea as one of the components and a salt having comparatively as high a degree of dissociation as the other, has been found to form any complex salt. The system KI-I_2 has been specially examined and found to give rise to the formation of KI_3 even in very dilute solutions. The paper contains abundant data in tables and curves, and a plate in illustration of the phenomena described. H. H. Ho.

1249. *Separation of Mercury into Isotopes in a Steel Apparatus.* **W. D. Harkins** and **S. L. Madorsky.** (Nature, 111. p. 148, Feb. 3, 1923.)—By 305 hours of repeated fractional vaporisation from a steel trough, in a vacuum at low pressures, a difference of 0·1 unit in the atomic weight of mercury has been obtained, without other cooling than that given by ice. The trough held 190 c.c. of mercury, and another larger apparatus has been constructed with a capacity of 10 kilos. The progress of the separation was followed by means of curves due to Mulliken and Harkins, and it was found that the efficiency of the process was quite constant, and equal to about eighty per cent. H. N. A.

1250. *Cored Crystals and Metallic Compounds.* **E. C. Bain.** (Chem. and Met. Eng. 28. pp. 65–69, Jan. 10, 1923.)—When a solid solution crystallises there is often a steep gradient of composition from the inside to the outside of the grain, depending on the dissimilar composition of liquid and solid. This gives rise to a diffused X-ray pattern, since the spacing of the lines of the spectrum is unequal for different pores of the crystal, *e.g.* in copper-gold alloys. This diffuseness can be removed completely by annealing when diffusion takes place and the solid solutions become uniform in composition throughout. Intermetallic compounds are usually brittle since they usually have complex lattices and give little opportunity for slip. T. M. L.

1251. *Nature of Solid Solutions.* **E. C. Bain.** (Chem. and Met. Eng. 28. pp. 21–24, Jan. 3, 1923.)—α-Brass contains the face-centred cubic lattice of copper expanded up to 2·2 % in linear dimensions by the presence of 35 atoms per cent. zinc. β-Brass containing equal numbers of atoms of both elements gives a body-centred cubic lattice, in which zinc atoms are found at the centre of simple cubes of copper-atoms and conversely. Further addition of zinc gives a γ-brass with a rhombohedral lattice, which has no ductility. The η-brasses which are very rich in zinc have the hexagonal lattice of zinc, with a few copper atoms replacing zinc.

In α-bronze the face-centred cubic lattice of copper may be expanded up to 1·5 % by 5 atoms per cent. of tin; but the volume expansion of the lattice is only one-half of that calculated from the atomic volumes of the two elements, showing that there is a definite attraction between Cu and Sn which is not found between Cu and Zn.

The presence of aluminium to the extent of 18·8 atoms per cent. expands the face-centred lattice of copper by only 0·91 per cent.; this is about one-third of the calculated expansion.

Cadmium expands the lattice of silver, but by less than the calculated amount; zinc produces a linear shrinkage of 1·36 per cent., but this is greater than the calculated amount, again suggesting an attraction between the unlike elements.

Iron and manganese give first the body-centred lattice of α-iron, with up to 30 per cent. of the atoms replaced by manganese; then a face-centred lattice corresponding with γ-iron; and finally, a manganese lattice, probably body-centred, with iron replacing some manganese.

Tungsten and molybdenum, although possessing a body-centred cubic lattice like iron, do not form a continuous series of solid solutions with it, as the compounds WFe and MoFe with a hexagonal lattice intervene at intermediate compositions. Tungsten and molybdenum form, however, with one another a continuous series of solid solutions of the body-centred type, the dimensions being almost constant throughout. Copper and nickel behave in a similar way, but have a face-centred cubic lattice. Silver and gold are similar, the dimensions of the lattice varying only by one-half per cent. from end to end of the series. The lattices of copper and gold differ by nearly 5 per cent. in linear dimensions; but the intermediate solid solutions are denser than the values calculated from the ordinary law of averages, suggesting that unlike atoms can be packed a little more closely than like atoms. **T. M. L.**

1252. *Influence of Structure on the Mechanical Properties of a Mixture.* **A. Portevin.** (Rev. de Mét. 20. pp. 49–62, Jan., 1923.)—Consider a mechanical mixture of two isotropic substances A and B having elastic limits E_A and E_B, maximum elastic elongations C_A and C_B, moduli of elasticity M_A and M_B, maximum strengths of R_A and R_B, elongations at fracture of λ_A and λ_B and hardnesses of Δ_A and Δ_B, where $E_A > E_B$ and $M_A > M_B$. The mechanical properties of a mixture of A and B containing, in unit volume xB and $(1-x)$A for different arrangements of A and B is worked out. For example, if the structure is lammellar then $E = E_B$; $\frac{1}{M} = \frac{1-x}{M_A} + \frac{x}{M_B}$, and $e = xe_B + \frac{E_B}{E_A}(1-x)$, if the force is normal to the lamellæ. The properties are also investigated where the force is parallel to the lamellæ, and for cases where the structure is cellular. Reference is also made to internal stresses due to thermal transformations, as well as to those of mechanical origin.

The variation of hardness with composition is studied in more detail, and it is shown that changes in direction of the hardness-composition curve may be found inside one-phase or two-phase fields at compositions corresponding to a change in the method of formation of one or other of the phases. **J. L. H.**

1253. *Preparation and Properties of Pure Iron Alloys.* I. *Effects of Carbon and Manganese on the Mechanical Properties of Pure Iron.* **R. P. Neville and J. R. Cain.** (Bureau of Standards, Sci. Papers, No. 453. pp. 411–443, 1922.)—Describes in detail the preparation of a series of very pure alloys of iron, carbon, and manganese, and the effect of carbon and manganese (from 0 to 1·6 % of each element) on the ultimate strength, Brinell hardness, limit of proportionality, elongation and reduction of area of pure iron. Pure electrolytic iron is electrically melted *in vacuo* in a magnesia-lined crucible. Carbon is added as an alloy of carbon and iron (4·45 % of carbon), and manganese in the pure state, to the molten metal. From the results of the various tests a series of curves are plotted. The effect of carbon content is shown by grouping according to manganese content and plotting properties against carbon content, in each group. Similarly with manganese, grouping according to carbon contents, the effects of which are allowed for after reference to the former curves. Carbon increases the ultimate strength, the Brinell hardness and, to a less extent, the limit of proportionality, and reduces the ductility, up to 1 % carbon. Above this the values for the first three properties fall off and those for the ductility remain fairly constant. Mn increases the ultimate strength, limit of proportionality, and Brinell hardness only slightly, and has very little effect on ductility. The presence of carbon augments the influence of manganese and *vice versa*. J. L. H.

1254. *Preparation and Properties of Pure Iron Alloys. III. Effect of Manganese on the Structure of Alloys of the Iron-Carbon System.* **H. S. Rawdon and F. Sillers, Jr.** (Bureau of Standards, Sci. Papers, No. 464. pp. 637–653, 1923.)—The effect of Mn as a hardening element in carbon steels, as distinct from its deoxidant and desulphurising effects, is studied in an extensive series of alloys, in conjunction with their corresponding microstructures. Steels containing 0–1·6 % C, and 0–2 % Mn, annealed and normalised, are included. The effect of Mn is described as a " restraining " influence, pearlite having, even after annealing, a fine-grained sorbitic structure, such as results ordinarily upon more rapid cooling. This is accompanied by a corresponding increase in mechanical properties. One per cent. of Mn lowers the eutectoid ratio from 0·9 % C. to 0·78 % C. In annealed alloys Mn has no influence on grain size, but in normalised alloys of high Mn content the grains are very much smaller than in similar alloys of low Mn content. A. B. C. L.

1255. *The Strengthening of Metals by Tensile Stress.* **J. Czochralski.** (Zeits. f. Metallkunde, 15. pp. 7–16, Jan., 1923.)—Examining the effects of tensile stress acting in various directions on multiple and single crystals of copper and other metals, the author points out that, contrary to expectation, the maximum load borne by single crystals in different directions fluctuates very much and may be much lower than the lowest values found for ordinary, multiple-crystal specimens, or may almost approach the maximum in other cases, whilst in multiple crystals maximum strength tends to go together with average elongation, and maximum elongation with average strength. Bars cut in the direction of maximum strength and mean elongation cannot be strengthened by intense stretching in the cold ; but bars taken in the direction of low strength can be strengthened by these means, most specimens attaining a fairly constant strength limit, such that the final material is practically isotropic, having approximately equal strengths in all directions. The author concludes that the possibility of forming slip planes does not increase, but does decrease, with increasing elongation, and he ascribes the phenomena of the strengthening and the flow of metals to the grouping of the atoms with crystal lattice ; there will be great strength in a certain direction when the number of atoms in the unit cross-section is great. Without slipping, the crystals might direct themselves with respect to the direction of the stress applied, as proposed by Polanyi, Körber, and others; but the experiments of W. Müller on the effect of rolling in different directions and some experiments by the author, do not support that assumption. A diagram is given, connecting the strength and elongation with the grain size, and it is suggested that the flow and strengthening phenomena are closely related to the internal friction in the sense of Ludwik.

H. B.

1256. *Experimental Production of Alloy Steels.* **H. W. Gillett** and **E. L. Mack.** (Bureau of Mines, Bull. 199. [81 pp.] Washington, 1922.)—A detailed and full report dealing with the experimental production of various alloy steels in a small indirect-arc electric furnace, and with the recovery and segregation of the various elements. A direct-arc furnace was found to be unsuccessful for such small scale work, as difficulty was experienced in controlling the carbon content of the steels. The recovery of tungsten, molybdenum, chromium, nickel, copper, and vanadium in amounts up to 1 per cent. is practically complete when the ferro alloy or metal is added to the furnace at the beginning of a heat. Uranium gives about 50 per cent. recovery only when added after the heat is finished or in the ladle. Otherwise the recovery is very low. Over 0·5 per cent. uranium causes marked segregation. Zirconium gives very low recoveries ranging from practically zero to about 60 per cent. according to the state in which the element is added. Ferro-titanium, if added at the end of the heat to a very hot bath, gives a fair recovery of titanium. Cerium (silico-cerium or ferro-cerium) is readily soluble in steel, but oxidises rapidly while standing—giving a reddish brown scum. Segregation is noted in all cases where more than 0·4 per cent. of cerium is present. It appears to act as a desulphuriser. Ferroboron, made by the Thermitt process with 17 per cent. boron, gives about 90 per cent. recovery and little segregation. Readily oxidised elements are best added to the ladle or to the furnace immediately after pouring. None of these elements appear to be as effective as aluminium or vanadium for degasifying.

J. L. H.

1257. *On the Changes in Iron and Steel at Temperatures below 280° C.* **F. C. Thompson** and **E. Whitehead.** (Roy. Soc., Proc. 102. pp. 587–599, Feb. 1, 1923.)—As a result of some unexpected facts observed during an investigation on the etching properties of the carbides in alloy steels, the study of the changes which are well known to occur in iron carbide was commenced. Since pure iron carbide was not to be obtained in bulk, the material used was a Swedish white pig iron which contained about 60 % Fe_3C. The remainder consisted of more or less pure iron, and the iron added for the different specimens was of 99·9 % purity. Iron itself shows abnormalities of the rates of increase of electrical resistance and electric potential against platinum at well-marked temperatures. Below 280° C., these temperatures are: 55°, 100°, 120°, 140°, 220°, and 245° C., of which 120° and 220° are the most important. It is difficult to believe that these can be of the nature of allotropic changes, and for the present no explanation is forthcoming. Under the same conditions carbide of iron possesses two well-marked points at 160° and 200°, but it is not clear whether these are distinct points or are the ends of a single transformation range. When samples of iron and high carbon steel are quenched from 280° C., it is found that the electrical resistivities differ from those obtained by slow cooling. These values are not constant, but as the material tempers they gradually alter until after a lapse of some days practical coincidence is obtained with those from the slow cooling experiments. The last section of the paper is devoted to a brief review of the work of previous investigators in this field. H. H. Ho.

1258. *The Calculation of Reaction Velocities.* **A. L. T. Moesveld.** (Zeits. phys. Chem. 103. pp. 481–485, Jan. 15, 1923.)—The method usually employed for the calculation of velocity constants consists in taking a series of readings of concentrations at different intervals and deriving the mean of the individual determinations of the velocity constant. On account of the incidence of the experimental error in this case, a more accurate method proposed is to employ the equation $\frac{1}{(A-x)^n} = k't + \frac{1}{A^n}$ where A is the initial concentration, x the amount converted at the time t, k' the velocity constant, and $n+1$ the order of the reaction. In the case of monomolecular reactions the expression has the form $\log\frac{1}{A-x} = k't + \log\frac{1}{A}$. The middle point is taken as zero for the time scale, readings before and after being taken at equal intervals, those before being expressed as negative. By using the method of least squares an evaluation is made of the two unknowns k' and $1/A^n$. In the case of a quadrimolecular reaction (where $n = 3$), which was investigated, the values of these quantities calculated from the constants determined agree closely with those measured experimentally. J. N. P.

1259. *Piezochemical Studies.* XVII. *Influence of Pressure on Reaction Velocity in Homogeneous Liquid Systems.* **A. L. T. Moesveld.** (Zeits. phys. Chem. 103. pp. 486–504, Jan. 15, 1923.)—An investigation is made of the influence of pressure on the reaction between hydrobromic and bromic acids in dilute aqueous solutions which proceeds in accordance with the equation: $5\,HBr + HBrO_3 = 3Br_2 + 3H_2O$. The ionic changes represented by this equation consist in the disappearance of 12 ions and the production of a non-electrolyte. In accordance with the diminishing electrostriction the change is accompanied by an increase in volume. It is found that, on account of intermediate stages through which this reaction proceeds, the order of the reaction is quadrimolecular. With increasing content of water the reaction velocity is slightly increased, while a retardation is produced by increasing the bromine content. A further deviation is produced by the formation of Br_3' ions. Measurements were on this account limited to solutions of the same initial concentration. The change of concentration during the reaction at different pressures was followed by means of the electrical conductivity measured with a dipping electrode. As the reacting acids are strong, changes in the degree of dissociation during the reaction are negligible. Special precautions are found necessary to avoid catalytic and absorption effects at the surface of the platinum-black-coated electrodes. Corrections are applied in the calculations for change of volume through temperature, pressure, and the progress of the reaction, and for the influence of temperature and pressure of conductivity. Measurements are made at temperatures from 1° C. to 39° C., and at pressures from 1 to 1500 atmos. The influence of pressure on reaction velocity is found to be independent of the temperature within this range. At 1500 atmos. the velocity constant is less by 15·4 % than at 1 atm. J. N. P.

1260. *Electrometric Determination of Sulphur in Soluble Sulphides.* **H. H. Willard and F. Fenwick.** (Am. Chem. Soc., J. 45. pp. 645–649, March, 1923.)—The electrometric end-point in the presence of sulphide with an ammoniacal silver solution is very sharp and gives very rapid and accurate results. W. R. C.

1261. *Titration Curves for some Common Acids and Bases as Determined by the Hydrogen Electrode.* **C. E. Davis, E. T. Oakes, and H. M. Salisbury.** (Ind. and Eng. Chem. 15. pp. 182–185, Feb., 1923.)—A series of electrometric titration curves in which the same standard procedure was employed throughout are given for hydrochloric, sulphuric, and orthophosphoric acid, primary calcium phosphate, and citric acid with sodium hydroxide and sodium carbonate. It is found necessary to conduct the titration in a vessel which is closed to avoid access of outside air. The electrode consisted of a platinum rod coated with platinum black. An interval of 3–5 min. was required between each addition of the reagent in order to attain equilibrium. The electrodes were cleaned after each titration by immersing in sulphuric acid-dichromate solution and washing in several renewals of boiling distilled water. Efficient stirring was found necessary during the measurements. The saturated potassium chloride-calomel electrode and saturated potassium chloride salt bridge were found most suitable. The hydrogen used was purified. Both the dibasic sulphuric acid and tribasic citric acid give curves similar to the monobasic hydrochloric acid in that there is only one inflection. The end-point with citric acid is less sharp. With orthophosphoric acid a sharp break is obtained for the first H-ion, an ill-defined break for the second, and no change is shown for the third. On titrating sodium carbonate with hydrochloric acid, the first inflection is not very abrupt, while the second inflection point is abrupt and steep, and the end point well-defined. Owing to differences in chemical reaction in some cases, as well as differences in the salt content of the solution, reversing the order of the titration does not result in titration curves that are mirror images of each other. The inflection points in different cases are compared with the change points given by different indicators. J. N. P.

1262. *On Cells Containing Fluorescent Liquid.* **A. Grumbach.** (Comptes Rendus, 176. pp. 88–90, Jan. 8, 1923.)—Two platinum electrodes immersed in a fluorescent solution form an electric cell when one is illuminated. The electromotive force varies with the time. Goldmann [see Abstract 265 (1909)] has compared cells of this kind with Becquerel actinometers, and has only found electromotive force to be set up when one of the electrodes was illuminated and not the intermediate liquid. In his work, which was carried out almost exclusively with alcoholic solutions, the electrode illuminated was positive. Goldmann employed saturated solutions of the fluorescent substance where the first liquid layers would absorb all the active radiation, so that e.m.f. only appeared if the electrode was very near the side or the free surface illuminated.

On the other hand the present author, by using dilute solutions, has established the fact that the origin of the phenomenon is not at the surface of the electrodes. Instead of illuminating an electrode, the cell has been entirely in the dark, and, near to one electrode, some of the same solution is introduced which has for 2 hours previously been exposed to light from a mercury arc filtered through water and concentrated by means of a glass lens. An e.m.f. appeared after this addition, and was found to be a function of the time. The time e.m.f. curve is similar to the one obtained by direct illumination of the electrode. The results are very good for a solution of uranine. The electrode used is at first found to be negative, but the e.m.f. passes through a maximum, decreases to zero, and changes sign. Experimental details are included in the paper and accompanied by data for solutions of uranine. As high an e.m.f. as 18 millivolts in 82 mins. has been obtained when using only the green radiation from a mercury arc. H. H. Ho.

1263. *The Apparent Irreversibility of the Calomel Electrode.* **A. W. Laubengayer.** (Am. Electrochem. Soc., Trans. 39. pp. 417–421, 1921.)—Tests to determine whether the irreversibility of the calomel electrode is real or only apparent. The observed phenomena of irreversibility are explained as due to the formation of an adsorbed film of mercurous chloride on the mercury anode, which offers high resistance to the passage of the current. A current of 0·2 milliampere can pass before the film forms. A number of points are not yet cleared up, and call for further study. [See also Abstract 1876 (1921).] AUTHOR.

1264. *Bismuth Salts in Aqueous Solutions and Electrode Potential of Bismuth.* **D. F. Smith.** (Am. Chem. Soc., J. 45. pp. 360–370, Feb., 1923.)—Determinations are given of the electrical conductivity of solutions of bismuth nitrate and oxynitrate solution, and also of the electrode potential of bismuth in bismuth perchlorate solution. The results of the measurements of solubility and electrical conductivity of solutions of bismuth nitrate containing various concentrations of nitric acid indicate that the bismuth exists as the partly ionised salt $Bi^{+++}(NO_3^-)_3$. The conductivity of solutions of bismuth perchlorate shows that the very soluble basic salt $Bi(OH)_2^+ClO_4^-$ has a conductivity of an unhydrolysed uni-univalent salt like potassium nitrate, and that it is converted into less basic salts such as $BiOH^{++}(ClO_4^-)_2$ and $Bi^{+++}(ClO_4^-)_3$ very slowly upon the addition of an excess of acid. When the ratio of perchlorate to bismuth is 4 : 1 not more than 40–50 % of the bismuth oxyperchlorate is converted into the hydroxy salt $BiOH(ClO_4)_2$. Electromotive force measurements upon solutions of bismuth perchlorate confirm the conclusions from conductivity measurements. The electrode potentials found were :

$$Bi(s),\ Bi^+O + H^+ : -\ 0{\cdot}314\ \text{volt};\quad Bi(s),\ BiOH^{++} + H^+\ -\ 0{\cdot}298\ \text{volt}.$$

F. J. B.

1265. *Electrode Potential of Bismuth.* **E. H. Swift.** (Am. Chem. Soc., J. 45. pp. 371–377, Feb., 1923.)—The electrode potential of bismuth was measured by equilibrium measurements, made between solutions of bismuth and copper perchlorate in perchloric acid solution. The equilibrum $3Cu + 2Bi(ClO_4)_3 = 2\,Bi + 3Cu(ClO_4)_2$ was approached from both sides, at a temperature of 25° C. Assuming that the bismuth exists as (1) BiO^+ or (2) as $Bi(OH)^{++}$, and that the perchloric acid present is completely ionised, the electrode potential of bismuth was calculated from the composition of the equilibrium mixture. The values referred to the hydrogen electrode were :

$$Bi(s),\ BiO^+ + H^+ : -0{\cdot}318 \text{ volt};\ Bi(s),\ Bi(OH)^{++} + H^+ + 310 \text{ volt}.$$

Regarding the copper salt as completely ionised, these values become $-0{\cdot}323$ and $-0{\cdot}314$ volt respectively, which are in fair agreement with the results of D. F. Smith, derived by electromotive force measurements. [See preceding Abstract.] F. J. B.

1266. *The Application of the Quinhydrone Electrode to Acidity Determinations.* **J. M. Kolthoff.** (Recueil des Trav. Chim. des Pays Bas, 42. pp. 186–198, Feb. 15, 1923.)—The potential of the quinone electrode in the form of a platinum plate immersed in a solution containing quinhydrone has, according to Biilmann, the following constants at 18° C. :

$$p\text{H or } -\frac{1}{\log C_H} = \frac{0{\cdot}4080 - \pi}{0{\cdot}0577}$$

where C_H is the concentration of $H^{\cdot}$ ions and π the potential of the electrode when combined with a normal calomel electrode. A method is by this means provided for measuring $H^{\cdot}$ ion concentration which has many advantages over the H_2 electrode. The potential attains a constant value more rapidly, and measurements can be made in a number of solutions in which, on account of interaction at the surface of the platinum, the hydrogen electrode is not applicable. On the other hand, in alkaline solutions, the values obtained with the quinone electrode are not in accordance with the above formula. This is due to the fact that hydroquinone itself acts as a weak acid with a dissociation constant of about 10^{-10} and in alkaline solutions is easily oxidised. This objection does not, however, preclude the electrode being used to indicate the end-point in the titration of acid solutions. Methods of preparing quinhydrone are described. The concentration in the solution to be measured is immaterial, and 100 mg. per 100 c.c. is sufficient. A small piece of platinum gauze is used as the electrode and comparative measurements made with prepared buffered solutions by both the hydrogen and the quinhydrone electrodes showed a close agreement. The readings obtained with the quinhydrone electrode during the titration of a number of different acids with different bases are plotted. J. N. P.

1267. *Behaviour of Cobalt Anodes in Alkaline Solutions.* **G. Grube** and **O. Feucht.** (Zeits. Elektrochem. 28. pp. 568–579, Dec. 1, 1922.)—The polarisation of cobalt anodes in alkaline solutions was investigated. Cobalt was deposited on platinum-foil electrodes from a strongly ammoniacal solution of cobalt sulphate. The cobalt sulphate was very carefully purified from the impurities, iron, aluminium, and nickel. The results showed that cobalt electrodes, in concentrated alkaline solutions and at low-current densities, passed into solution, as a divalent metal and formed potassium cobaltite. The equilibrium potential of cobalt in a solution of potassium cobaltite in 8 *n*. KOH was measured. The electrode potential of cobalt in a molar solution of potassium cobaltite in 8 *n*. KOH at 25° C. was calculated to be $\epsilon_h = -0{\cdot}52$ volt, from the above measurements. Dates were also furnished as to the cobalt anion complex. The anodic oxidation of cobalt on platinum takes place in three stages. At low potentials the oxide Co_3O_4 is formed, at medium high potentials the oxide Co_2O_3, and at high potentials a solid solution of CoO_2 in the lower oxide is formed, with simultaneous evolution of oxygen. The electrolytic evolution of oxygen on cobalt anodes in alkaline solutions takes place so that the atomic oxygen which is discharged reacts with the cobalt to form CoO_2, and this decomposes spontaneously into free oxygen and Co_2O_3. F. J. B.

1268. *The Significance of the Electrode Potential.* **J. Heyrovský.** (Roy. Soc., Proc. 102. pp. 628–640, Feb. 1, 1923.)—The reaction by which all metallic electrodes become charged when in contact with an aqueous solution is considered to be represented by the equation: $Me + OH' \longrightarrow MeOH + \ominus$, whereby metal is ionised at the surface, combines with a hydroxyl ion and leaves a negative electron at the metallic electrode. The charging proceeds until an equilibrium stage is reached when, by electrostatic action, the kations in the proximity of the electrode are attracted and deposited at the same rate as the loss of atoms which are extracted from the metal by OH′ ions. By introducing the physical conception of the "electron affinity" a determination is made of the change of energy which occurs in the reversible transfer from free metal to ions in solution in terms of the known ionisation potential of the metal. The values for the following different stages of a cycle are added and equated to zero: (1) The vaporisation of a gramme-atom of metal under its vapour pressure *p*. (2) The transfer to an ionisation chamber of 1 grm.-molecule of water-vapour from the solution surrounding the electrode and expansion to the pressure *p*. (3) The ionisation of the metallic vapour and of the water-vapour into $H^{\cdot}$ and OH' ions. (4) The combination of $Me^{\cdot}$ ions with the OH' ions to form MeOH. (5) The transfer of $H^{\cdot}$ ions and MeOH molecules from the ionisation chamber to the solution surrounding the electrodes. (6) The transfer of free electrons from the ionisation chamber to the electrode. (7) The hydration of MeOH and $H^{\cdot}$. The following reaction then proceeds at equilibrium concentration and involves no change in work:

$$MeOH + H^{\cdot} \longrightarrow Me^{\cdot} + H_2O,$$

(8) The transfer of 1 grm.-kation of $Me^{\cdot}$ ions from the solution back to the metallic surface. The expression finally obtained is as follows:

$$\pi = K - \frac{RT}{F}\log p + J - M - \frac{RT}{F}\log K_b + \frac{RT}{F}\log C_{Me^{\cdot}}$$

where π is the electrode potential; K, a term to include all factors which do not vary with the nature of the metal; J, the ionisation potential; F, Faraday's constant; M, the work necessary to ionise the molecule MeOH into its ions in the gaseous state; K_b the basicity constant or the expression $C_{OH'} . C_{Me^{\cdot}}/C_{MeOH}$. The electrolytic potential is thus seen to be increasingly negative with metals with a small ionisation potential (*e.g.* the alkali metals), with very compact molecules which have a large value of M (*e.g.* lithium) and with metals of high basicity constant. The last term of the above equation expresses the dependence of the potential on the concentration of the ions; all the other terms summarised denote Nernst's expression of "solution tension." The basicity constant is also shown from other considerations to increase with the equivalent weight of the element. The charges acquired according to this view by any metal in aqueous solution always should be negative. In the case of the most noble metals the values are uncertain through the electrodes acting as gaseous electrodes.

The "absolute zero potential" value derived from the electro-capillary phenomena with mercury is considered to be illusory, the probable value occurring at some point between silver and chlorine. Hydrogen overvoltage is explained by the consideration that atomic hydrogen has a more highly negative potential than that of any metal, the energy of the reaction $H^{\cdot} + OH' \longrightarrow HOH$ being larger than in the case of the most positive metals. A steady deposition of $H^{\cdot}$ atoms can therefore only occur in aqueous solutions through the action of catalytic or absorbing action of the electrode surface whereby molecular hydrogen is formed.

J. N. P.

1269. *Transference Numbers of KOH.* **M. Knobel, D. K. Worcester, and F. B. Briggs.** (Am. Chem. Soc., J. 45. pp. 77–79, Jan., 1923.)—The transference number of the K ion was found to be constant and equal to 0·2633 in the range of concentrations from 3N to 0·001N and to increase with decrease in concentration.

A. D.

1270. *Ions of Potassium Hydroxide.* **M. Knobel.** (Am. Chem. Soc., J. 45. pp. 70–76, Jan., 1923.)—Electromotive forces of cells of the type $H_2 \mid KOH(C_1) \mid KHg_x \mid KHg_x \mid KOH(C_2) \mid H_2$ measured at 25° C. for concentrations of KOH ranging from 3N to 0·001N. Activity-coefficients of the ions of the solution at various concentrations and the free energy of dilution between various concentrations calculated and tabulated. Data given by Chow (Am. Chem. Soc., J. 42. p. 488, 1920) found incorrect. The relation between the activity and the concentration for KOH found similar to that for other non-univalent electrolytes.

A. D.

1271. *Ionisation by the Hydration of Sulphate of Quinine.* **[Mlle] Chamie.** (Comptes Rendus, 176. pp. 251–253, Jan. 22, 1923.)—This paper does not lend itself to abstracting. [See also Abstracts 776 (1911) and 1801 (1922).]

F. J. B.

1272. *Structure of Electro-Deposited Metal.* **W. E. Hughes.** (Beama, 12. pp. 215–225, April, 1923.)—The author deals with the various factors affecting the structure of electro-deposited metal. The article is illustrated by microphotographs.

W. R. C.

1273. *Electro-Chemical Effects Produced by Superimposing Alternating Currents upon Direct Currents.* **W. R. Cooper.** (Faraday Soc., Trans. 18. pp. 102–111; Disc., 111, Oct., 1922.)—Both low-frequency and high-frequency currents were superimposed on a continuous current. The alternating current was varied so that experiments were made both when the amplitude was lower and also greater than the value of the direct current. The superimposed currents had no effect on the kathode gain or anode loss in the electro-deposition of copper from copper sulphate. The effect of the superimposed current when platinum wire electrodes are used in dilute sulphuric acid is to cause an increase in the direct current. The effect varies with the values of both the direct and superimposed currents, and it takes time to pass off. In the case of low-frequency currents the greatest sensitiveness appears to be obtained when the d.c. voltage applied to the electrolyte is below that of decomposition. In some of the experiments the electrodes were viewed under the microscope, and it was noticeable that with currents of, say, one milliampere or rather less the whole of the hydrogen was absorbed for a considerable period by the kathode, although oxygen was being given off freely at the anode. The effect with high-frequency currents was similar, but was not apparent to the same extent until the d.c. voltage was considerably higher. By using one large electrode and one platinum wire electrode just dipping into the electrolyte the high-frequency current produced a spark discharge in the body of the electrolyte near the wire under suitable conditions. AUTHOR.

1274. *Electrolytic Manufacture of Paraminophenol.* **A. S. McDaniel, L. Schneider,** and **A. Ballard.** (Am. Electrochem. Soc., Trans. 39. pp. 441–449; Disc., 449–450, 1921.)—Paraminophenol sulphate was made by electrolysing nitrobenzene in solution in strong sulphuric acid as a katholyte, using platinum electrodes, with a kathode-current density of 3–4 amp. per sq. d.cm., and anode density double. Ice cooling was necessary for the best yields. Diaphragms were used of thin dense unglazed porcelain. Sulphuric acid was used as anolyte. All the nitrobenzene was reduced at an ampere efficiency of approximately 50 per cent.; the other products were mainly sulphonic acid and aniline. The product was centrifuged and treated with HCl, giving paraminophenol hydrochloride of high purity. AUTHOR.

1275. *Electrolytic Iron.* **W. A. Noyes, Jr.** (Am. Electrochem. Soc., Trans. 39. pp. 451–458, 1921.)—Deals particularly with the minimum potential at which the electrolytic deposition of iron can be carried out. Comparative figures are given relating to nickel. W. R. C.

1276. *Preparation of Solid Alkali Amalgams by Electrolysis.* **P. M. Giesy** and **J. R. Withrow.** (Indust. and Eng. Chem. 15. pp. 57–60, Jan., 1923.)—Solid amalgams of the alkali metals are stated to be of value as reagents in a number of lines of work, and a rapid and easy method of preparing them in quantity was desired. The ordinary chemical method of preparing these requires care to avoid explosions, and therefore they are usually produced under xylol, paraffin, or petrol in order to prevent accidents [see Abstract 1292 (1903)]. The electrolytic method of preparation from salts of the alkali metals is therefore attractive, although it does not give the strong amalgams which may be produced by chemical methods. Records rarely show more than 2·30 % of potassium, and the authors' results did not exceed this concentration. In the present work

(1) the methods and apparatus of Arlt, Nernst, Kerp, and Böttger were simplified, and their efficiency was greatly increased; (2) the method modified by G. McP. Smith and Bennett was also changed, in order eventually to maintain it as the more rapid method; (3) Shepherd's method was modified by the use of different diaphragms, but trouble was experienced through endosmosis and diaphragm disintegration. The conclusions arrived at by the authors as the results of their investigations were:

(1) Kerp's method for electro-preparation of amalgams can be greatly simplified and improved, by allowing the mercury in the bottom of the cell, as well as that from the flowing jet, to receive a current. In this way, the current can be increased many-fold with a corresponding reduction in manipulation, and in the time of run. (2) If the current be led out at the tip of the jet-tube, a single jet-tube, with a stop-cock, can be used instead of the changeable jets used by Kerp. (3) To produce a pure product, it is not necessary to run in an atmosphere of hydrogen. (4) Smith and Bennett's method can be improved, by forcing the current (and also for use in producing sodium amalgam, for which it was none too satisfactory) by cooling the electrolyte strongly. The use of a higher current reduces the time required for individual runs. (5) If a suitable diaphragm could be found, Shepherd's method would undoubtedly be the best. (6) Such a diaphragm would have to be unacted upon by solutions of caustic alkalies; by the amalgams themselves; offer low electrical resistance; and be a non-conductor. No such material was found. (7) All the solid alkali-metal amalgams made were found to float in mercury, and even potassium amalgam which, disintegrated, gave fragments which could be felt at the surface of the mercury, and no pieces could be found at the bottom. Slow cooling of potassium amalgam gave larger crystals, which were visible at the surface of the mercury-amalgam solution. Added to pure mercury they disappeared, but a skimming operation with a watch glass at the surface of the mercury recovered most of the amalgam crystals. In runs 6, 10, 11, and 13, solid sodium amalgam was visible in chunks floating at the surface of the liquid amalgam. These indications confirm the contention previously made, that all alkali-metal amalgams are probably lighter than mercury, in contradistinction to the sinking of the amalgam, recorded by Kerp.

J. B. C. K.

1277. *A Low Temperature Electrolyte.* **W. H. Rodebush** and **T. O. Yntema.** (Am. Chem. Soc., J. 45. pp. 332–337, Feb., 1923.)—The authors' attention was called by W. A. Noyes to the fact that a mixture of NO and HCl condensers at liquid-air temperature to a solid of intense purple colour which, upon warming, dissociates into the original constituents. This appeared to be the only certain exception to the generalisation of G. N. Lewis [see Abstract 946 (1916)] that molecules containing an odd number of electrons are coloured. The prediction was made that if the compound (assuming it to be such) could be liquefied without the colour disappearing, it would show a very considerable electrical conductivity. An apparatus convenient for working with gases at a low temperature and also a low temperature thermostat are described, and a maximum specific conductivity found for a liquid phase which is greater than 10^{-3} mhos between 120° and 130° K. When an attempt was made to work with compositions nearly equimolecular, it was found that the gases tended to condense separately as pure solid phases with the dividing surface brilliantly coloured. On warming, the nitric oxide evaporated leaving the hydrogen chloride as a pure white solid. By raising the pressure to 15–20 atmos., the NO was prevented from evaporating until the HCl had melted to a considerable extent, but the homogeneous liquid phase was without colour or conductivity, a fact which indicated that the complex dissociated completely above about 130° K. It was found that compositions of about 1 mol. HCl to 3 mols. NO when condensed in as intimate contact as possible, melted to form a liquid of a dense purple colour with the conductivity stated above. This liquid was easier to produce by condensing the gases over a layer of petroleum ether, an effect which seemed to be purely mechanical. A definite determination of composition appeared to be out of the question, but the experimental evidence pointed to a simple molecular complex. How unstable this must be is apparent from the fact that the partial pressure of liquid NO is not appreciably lowered by the presence of an excess of solid HCl. The molecular complex is probably $[NOH]^+Cl^-$ and exhibits the properties of an "odd" molecule. The behaviour of the conductivity is that usually found in solvents of low dielectric constant, and it falls to low values for compositions where either constituent is present in great excess. **H. H. Ho.**

1278. *The Anomaly of Strong Electrolytes.* **H. J. S. Sand.** (Phil. Mag. 45. pp. 129–144, Jan., and pp. 281–292, Feb. 1923.)—The theories advanced by Ghosh [Abstracts 881 (1918), 104 and 223 (1919)] and by Milner (Phil. Mag. 35, pp. 214, 352, 1918) are investigated and criticised. Calculations are made of the degree of association of a completely ionised electrolyte immersed in a medium of uniform dielectric constant, use being made of Boltzmann's theorem and of Born's theory regarding the potential energy of a pair of attracting ions. The probability of contact between the two ions of a binary electrolyte in a given small volume of decinormal solution is found to be 8·1 times the probability of their occurrence in any two volumes of the same size situated so that the attraction between the ions is negligibly small. Complete ionisation of salts such as sodium chloride is hence regarded as established, and proof is given of the obedience of a preponderating proportion of the ions to the inverse square law of electrical action. The space lattices of Ghosh's theory of the crystalline arrangement of the ions in aqueous solution are regarded as merely theoretical distributions of reference. With reference to Ghosh's and Milner's osmotic pressure formulæ, the mean values of $(2 - i)$ obtained experimentally for univalent binary chlorides in aqueous solutions agree well with those deduced from Ghosh's formula, the agreement being closer for higher concentrations than that given by Milner's expression. The statement of Ghosh's subsidiary hypothesis is corrected so as to make these agree with his mathematical formulæ. Although the theory is, on the whole, strengthened thereby, the number of stated and implied subsidiary hypotheses is so great that the deductions drawn from them cannot be considered essentially different from empirical formulæ. Reasons are given to show that hindrances to conduction arising from the electric fields due to ions in a completely dissociated electrolyte dissolved in a medium of uniform dielectric constant would be of the nature of polarisation in the liquid itself; its conductivity should be greater with rapidly alternating currents and under very high potential gradients than with constant small potential gradients. Owing to the absence of such effects as these, the idea of a solvent medium of continuous dielectric constant is abandoned; Milner previously arrived at this result on different grounds. The nature of the dielectric properties of the solvent as well as its rôle in determining whether an ion is free or bound at a given instant is considered, and the importance of the rotational and vibrational energy of molecules of solvent and solvated ions emphasised. T. H. P.

1279. *Electrolysis with a Dropping Mercury Kathode.* **J. Heyrovský.** (Phil. Mag. 45. pp. 303–315, Feb., 1923.)—A study is made of the kathode deposition of the most positive metals by the use of dropping mercury proceeding from a capillary tube as kathode. The advantages offered by this method are the high overvoltage and the avoidance of concentration polarisation through the presence always of a fresh and pure mercury surface; further, the drops when falling on the bottom mercury used as anode produce stirring there and enable the layer of mercury to be relied upon as an exact reference electrode. With this arrangement, even calcium and magnesium can be deposited in mercury before hydrogen is evolved. The formation of amalgam can be followed by observing the shape of the electro-capillary parabola obtained by the drop weight method. When amalgam formation begins, the descending branch of the parabola turns horizontal. A more accurate method adopted, however, consists in determining the increase of current caused by the gradual increase of the polarising e.m.f. In accordance with theory, the slightest polarisation deposits some kations on the surface of the mercury drops and forms an extremely dilute amalgam. With increasing polarisation, the current increases at first very slowly until the decomposition potential is reached, when a rapid increase of the current occurs. In the case of most solutions the decomposition potential could be fixed to within 2 to 4 millivolts. The more dilute solutions have a higher decomposition e.m.f., the differences for a tenfold dilution of a univalent salt amounting to 110 millivolts, and for a dibasic salt to about 80 millivolts according to the well-known difference of free energies at these dilutions [cf. McInnes and Parker, Abstract 1484 (1915)]. During the measurement the exact p.d. of the bottom electrode from that of the normal calomel electrode was determined; the difference between the two electrodes never exceeded 2 mv. Measurements with the different salts of the same metal showed that the decomposition potential is independent of the anion. Determinations are made of the values of π_N which is the deposition potential of the kation from a solution containing 1 grm.-ion per litre. The presence of acid leads to the evolution of hydrogen before the metal is deposited, while the presence of alkali stabilises the overvoltage, but changes the potential of the resting mercury for which it is necessary to correct. The concentration of the amalgam in the drop surface at the deposition potential can be estimated from the investigations of G. N. Lewis [Abstracts 1562 (1913), 1786 (1915)] on the alkali-metal amalgam potentials.

The deposition potential depends both on the affinity of the metal for mercury and its electrolytic potential, and indicates thermodynamically the very small partial pressure the alkali metal has in the drop surface; the combination with mercury having lowered the activity of the alkali metal, indicated by its electrolytic potential (E.P.) to the value π_N. Thus the affinity A of the metal for mercury is equal to π_N − E.P. From the work of G. N. Lewis and the values π_N we have:

Metal.	E.P.	π_N	$A = \pi_N - E.P.$
Li	− 3·304	− 2·023	1·281
Na	− 2·998	− 1·860	1·138
K	− 3·208	− 1·883	1·325
Rb	− 3·205	− 1·796	1·409
Cs	(− 3·3)	− 1·837	(1·5)

The affinity is expressed in volt-faradays per grm.-atom. Sodium has an anomalous position and behaves like a noble metal, its amalgam being very stable [cf. McP. Smith, Abstract 1504 (1908)]. The affinity of caesium for mercury, which from extrapolation would amount to 1·5 volts, points to the E.P. of this metal being − 3·5 volts from the calomel electrode. Other substances investigated are NH_4, Ca, Mg, Sr, and Ba.

J. N. P.

1280. *Influence of Neutral Salts on the Potential of the Hydrogen Electrode.* **W. A. Arkadjev.** (Zeits. phys. Chem. 104. pp. 192–202, March, 1923.)—Measurements are made of the potential given by a hydrogen electrode in conjunction with a normal calomel electrode in an electrolyte of 0·1 N hydrobromic acid in presence of varying amounts of several neutral salts. The influence of the neutral salt is to increase the potential of the cell, or to make the hydrogen electrode more noble, and the effect is proportional to the concentration of the salt. For a given concentration, the effect is proportional to the tendency of the salt to form hydrates, increasing, with the salts tried, in the order, KNO_3, KCl, KBr, NaCl, LiCl, LiBr. In the case of LiBr, a solution containing 10 grm. mol. per litre caused an increase in the hydrogen potential of 193·7 millivolts. It is noteworthy that KBr and LiBr, which have an anion common to that of the acid, have a larger effect than the corresponding chlorides. The results are in agreement with the conclusions of Sachanov, who determined the influence of neutral salts on the potential of acids with the hydrogen electrode and on that of salts with metal electrodes. A résumé is given of the conclusions of earlier work relating to the influence of ions and neutral molecules in solution in modifying dissociation. The bearing of this factor in accounting for the deviations from Ostwald's dilution law is discussed and the theories which have been considered, including those of the increase of dielectric constant, catalytic action, and dehydration phenomena. The present results are attributed to dehydration of the H ions through the hydration of the salt molecules, the electrode equilibrium being determined by the concentration of the non-hydrated ions.

J. N. P.